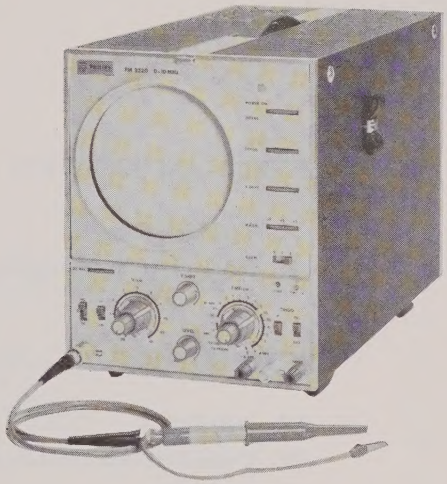
647

PHILIPS

10 MHz OSCILLOSCOPE PM 3220
10 MHz OSCILLOSCOPE WITH DELAY LINE PM 3221

66 405 38.1-10 10/666/01



PHILIPS

Service and operating manual

10 MHz OSCILLOSCOPE PM 3220
10 MHz OSCILLOSCOPE WITH DELAY LINE PM 3221

66 405 38.1-10 10/666/01

Contents

GENERAL INFORMATION

I. Technical data 5
II. Block diagram description 10

DIRECTIONS FOR USE AND APPLICATIONS

III. Installation 13
IV. Control elements and their functions 15
V. Operation 18
VI. Applications 21

SERVICE NOTES

VII. Circuit description 27
VIII. Gaining access to parts 36
IX. Maintenance 38
X. Adjusting elements and their functions 39
XI. Checking and adjusting 40
XII. Replacing parts 53
XIII. Gaining acces to the parts 57
XIV. List of parts 59

IMPORTANT

In correspondence concerning this apparatus, please quote the type number and the serial number as given on the type plate at the back of the apparatus.

List of figures

1	Front view	4
2	Accessories	9
3	Block diagram	10
4	Knobs and connection terminals	14
5	Rear view	16
6	Removing the knobs	36
7	Bottom view with high voltage unit	37
8	Side view (left)	40
9	Side view (right)	41
10	Square-wave reproduction	45
11	Adjusting the trimmer in the measuring probe	52
12	Mounting diagram of the attenuator measuring probe	54
13	Mounting diagram of the measuring probe cable	55
14	Front view with item numbers	60
15	Rear view with item numbers	61
16	Left side view with item numbers	62
17	Right side view with item numbers	63
18	Print plate U2, Y-amplifier	69
19	Circuit diagram, Y-amplifier	72
20	Oscillograms	75
21	Print plate U3, time-base generator, X-amplifier, supply section	76
22	Circuit diagram, time-base generator and X-amplifier	78
23	Time-base switch	82
24	Print plate U4, high voltage unit	83
25	Circuit diagram, high voltage unit	84
26	Circuit diagram, CRT circuit	85
27	Circuit diagram, supply section	89

Fig. 1. Front view

GENERAL INFORMATION

Technical data

The extensively transistorised PHILIPS electron-beam oscilloscopes PM 3220 and PM 3221 are identical in all respects, with the exception that the PM 3221 is equipped with a delay line.

Note: Properties expressed in numerical values with tolerances stated are guaranteed by the factory. Numerical values without tolerances stated represent the properties of an average apparatus and merely serve as a guide. The following data apply in case of nominal mains voltage, unless otherwise stated.

Cathode ray tube

Tube: – type	D13-27 GH, flat screen Screen diameter 13 cm.
– phosphor	Average persistance, green.
– useful screen area	10 × 8 cm.
– total acceleration voltage	3 kV
Unblanking	d.c. coupled
Brightness modulation (Z-MOD)	
– required voltage	20 V_{p-p} for frequencies of 10 Hz-1 MHz
– input impedance	1 MΩ//40 pF
– input RC time	10 ms
Measuring graticule	10 × 8 cm with intermediate divisions of 2 mm along the main axes. Graticule illumination in steps is possible.

Y-amplifier

Type of amplifier	d.c. amplifier
Input	
– input circuit	asymmetrical, AC-O-DC selectable

– input socket	BNC connector
– input impedance	1 MΩ//30 pF
– maximum permissible input voltage	500 V_p (d.c. voltage + a.c. voltage, also when the blocking capacitor is used).
– input RC time	0.1 sec. (in position AC).
Deflection coefficient	adjustable to 11 calibrated values, i.e.: 10, 20, 50 etc. mV/cm . . . 20 V/cm. Tolerance: ± 3% Bandwidth: DC-10 MHz (-3 dB) (10 Hz to 10 MHz on AC) Continuous (non-calibrated) adjustment between steps is possible. The sensitivity can be increased by means of a switch to: 1, 2, 5, etc. mV/cm . . . 2 V/cm. The bandwidth is then: DC-2 MHz (-3 dB) (10 Hz to 2 MHz on AC).
Rise time	35 ns or 175 ns respectively.
Overshoot	$\leqslant$ 1% for pulses having a rise time $\geqslant$ 10 ns.
Magnification	Up to 3 × the useful screen height for frequencies up to 0.1 MHz The peaks of a displayed picture having maximum amplitude, can be displayed by means of the shift control.
Delay (only for PM 3221)	An effective delay of $\geqslant$ 100 ns is obtained by means of a built-in delay line
Calibration voltage	Square-wave voltage of 5 V_{p-p}, ± 1%. Frequency 8 kHz

X-amplifier

Type of amplifier	d.c. amplifier
Input	
– input circuit	asymmetrical
– input sockets	4 mm sockets
– input impedance	0.5 MΩ//90 pF

– maximum permissible input voltage	50 V_p (d.c. voltage + a.c. voltage)
Deflection coefficient	adjustable to 3 values: 1000, 500 and 200 mV/cm.
Frequency response curve	0-1.5 MHz (-3 dB) at a deflection coefficient of 1 V/cm.
Deflection voltage	selectable: internal time-base voltage external voltage

Time-base generator

Time coefficient (without magnification)	Adjustable to 19 calibrated values, i.e. 0.5; 1; 2, etc. μs/cm . . . 0.5 s/cm. Tolerance: ± 5%. In the range 0.5 s/cm: ± 10%. Continuous adjustment between the steps is possible. The time-base switch also has a position T.V. LINE (time coefficient 2-10 μs/cm; continuously adjustable) and T.V. FRAME (time coefficient 0.5-2.5 ms/cm; continuously adjustable).
Sweep expansion	1, 2 or 5 × the useful screen width. With maximum expansion, the ends of the time base line can be displayed by means of the X-shift control. The maximum time coefficient that can be obtained is 100 ns/cm
Mode of operation	Triggered. The trigger stability can be adjusted on the front of the instrument (screwdriver adjustment).
Triggering – Source	Internal or external
– Polarity	+ or —
– Mode of Operation	AC, AUT, TV LINE, TV FRAME } coupled to the time base switch.
– Trigger sensitivity	Internal 0.5 cm 10 Hz-2 MHz, AC coupled 20 Hz-2 MHz, AUT 2 cm 5 Hz-10 MHz, AC coupled External 1 V_{p-p} Maximum permissible voltage in view of cross-talk: 12 V_{p-p}.

– Input impedance for the external trigger voltage	100 kΩ//20 pF
– Trigger level	
internal	Continuously adjustable over 6 cm.
external	Continuously adjustable over 4 V_{p-p}
Time-base voltage on the output socket	8 V_{p-p}

Power supply

– Mains voltage	Adjustable for mains voltages of 110, 125, 145, 200, 220 and 245 V
– Mains frequency	40-400 Hz. At mains frequencies lower than 50 Hz, the mains voltage may not exceed the nominal value.
– Power consumption	70 W
Effect of mains voltage variations of + or —10%	The deflection and time coefficients will not vary more than 4%. The calibration voltage remains constant.
Ambient temperature	The instrument operates in accordance with the tolerances at an ambient temperature between 0 and +35 °C. The instrument can be used at an ambient temperature between — 15 °C and +45 °C.

Mechanical Data

a. Dimensions	Height : 27 cm Depth : 38 cm Width : 20 cm
b. Weight	8.5 kg

Accessories

	Operating and Service Manual
Optional accessories available	Adapter PM 9051 (BNC → 4 mm) 10 : 1 attenuator probe PM 9326A/10 1 : 1 measuring probe PM 9325

Technical data PM 9326A/10

Attenuation	:	1 : 10, ± 3%
Input impedance	:	10 MΩ//12 pF
Maximum permissible input voltage	:	1000 V_{p-p}. Maximum permissible d.c. voltage component when the blocking capacitor is switched on: 500 V

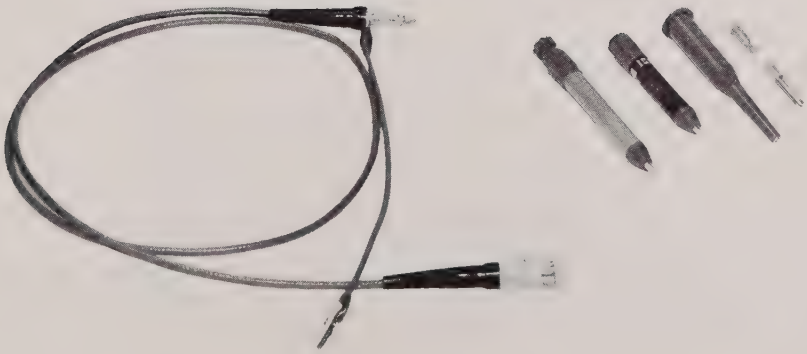


Fig. 2. Accessories

Block diagram description

Y-amplifier

The Y-amplifier is a d.c. amplifier consisting of:
- an input step attenuator
- a cathode follower input stage
- a pre-amplifier
- an output stage, delivering the deflection voltage for the picture tube.

In the PM 3221, the coupling between the pre-amplifier and the output stage has been effected via a delay line. This line has been applied so as to make it possible to display the leading edge of rapid phenomena on the screen.

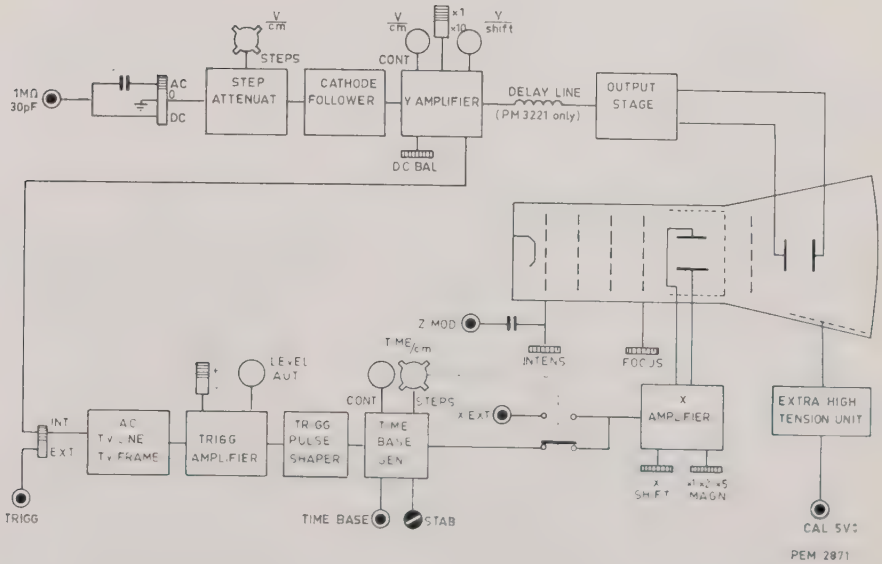


Fig. 3. Block diagram

Time-base generator

The time-base generator is of the Bootstrap integrator type.
It includes the charging capacitors and resistors which can be selected by means of knob TIME/cm. Continuous adjustment of the time coefficients is effected with potentiometer TIME/cm.
The stability of the time-base generator can be adjusted with screwdriver adjustment STAB.
The sawtooth voltage is available for external purposes on output terminal TIME BASE.

X-amplifier

The X-amplifier serves to amplify the internal sawtooth voltage or an external deflection voltage before these are applied to the X-deflection plates.
This circuit also includes the X-shift control and the magnification switch.

Trigger amplifier

The trigger amplifier amplifies the trigger signal coming from the Y-amplifier, or from an external voltage source.
The polarity of the trigger signal and the trigger level can be adjusted.

Trigger pulse shaper

The trigger pulse shaper delivers characteristic trigger pulses for starting the time-base generator.
The synchronisation separator for T.V. signals has also been included in the trigger unit, with the result that triggering at these signals is possible.

Cathode ray tube

Adjusting elements INTENS and FOCUS control the voltages on the various electrodes of the cathode ray tube.
The high voltages for the cathode ray tube are generated with the aid of a converter, which also delivers the calibration voltage of 5 V_{p-p}.
The Wehnelt cylinder is accessible for external Z-modulation via a connection terminal.

DIRECTIONS FOR USE AND APPLICATIONS

Installation

1. Adjusting to the local mains voltage

The oscilloscope can be adjusted to mains voltages of 110 V, 125 V, 145 V, 200 V, 220 V and 245 V by means of the voltage adapter on the rear. The adjusted voltage can be read through the opening in the cover plate.

2. Fuse

A 1 A fuse (delayed-action) is fitted in the holder at the rear of the instrument.
When the instrument is connected to a mains voltage of less than 200 V, a 2 A fuse should be used.

3. Earthing

The instrument can be earthed via terminal ⏚ on the front or rear of the instrument, or via the mains flex if this is equipped with a plug with rim-earthing contacts.
Double earthing causes hum and should therefore be avoided.

4. Switching on

The instrument is switched on by means of switch POWER ON.
The signal lamp will then light up.

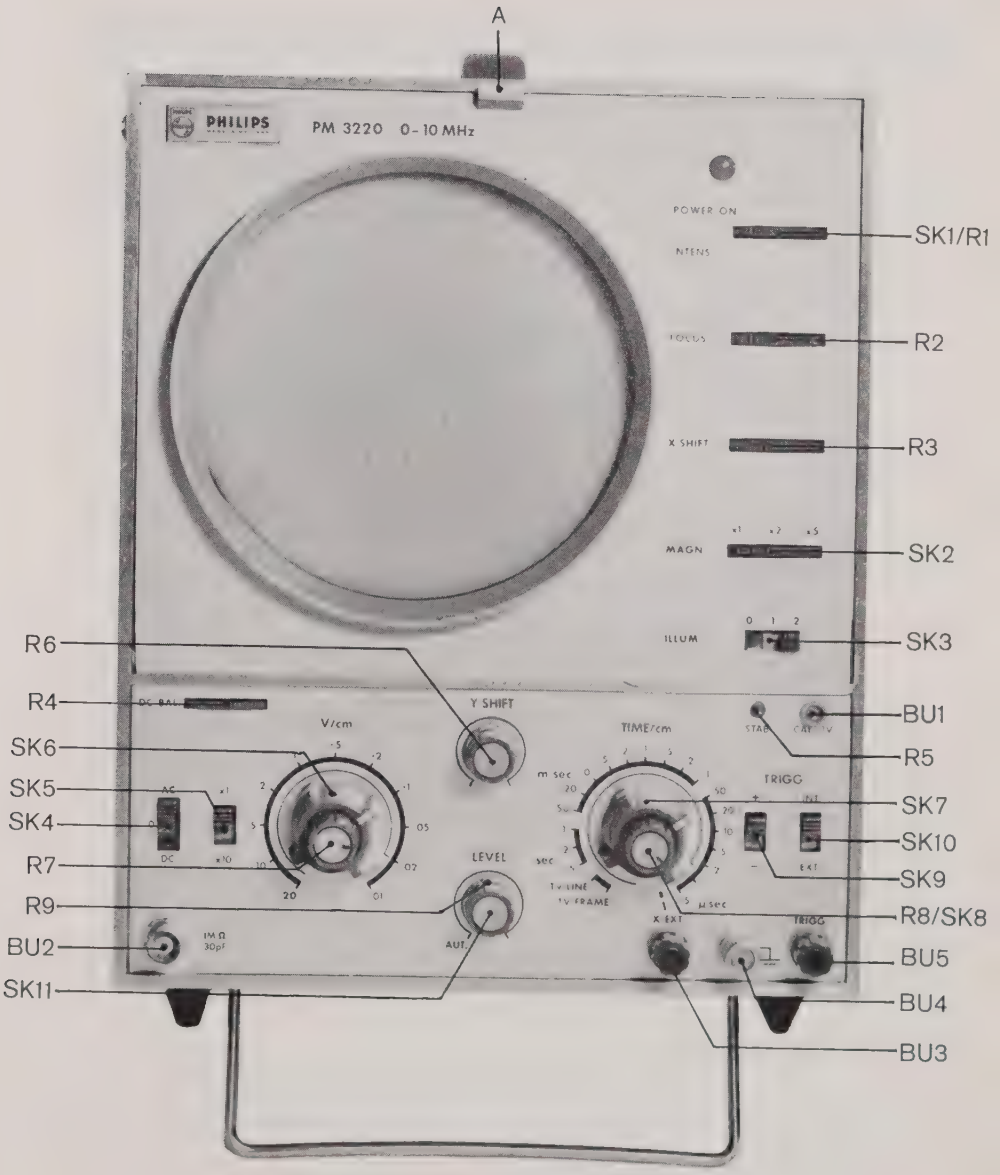


Fig. 4. Knobs and connection terminals

Control elements and their functions

IV

SK1/R1	POWER ON INTENS	Switching on and adjusting the brightness
R2	FOCUS	Adjusting the focus
R3	X-SHIFT	Horizontal shift
SK2	MAGN.	Expanding the time base length and adjusting the deflection coefficient of the X-amplifier.
SK3	ILLUM.	Step adjustment of the graticule illumination
R4	DC BAL.	Adjusting the d.c. balance of the Y-amplifier
R5	STAB.	Adjusting the trigger stability
BU1	CAL. 5 V	Square-wave calibration voltage having a frequency of 8 kHz
R6	Y-SHIFT	Vertical shift
SK4	AC-O-DC	AC: Connection between input and Y-amplifier via an isolating capacitor. O: Connection between input and Y-amplifier is interrupted. Amplifier input is earthed. DC: Direct connection between input and Y-amplifier.
SK5	×1-×10	×1: Deflection coefficients are as shown on the text plate. ×10: Deflection coefficients are 10× as small as shown on the text plate. The bandwidth is then limited to 2 MHz.
SK6	V/cm	Step control of the Y-deflection coefficients.
R7	V/cm-CAL	Continuous adjustment of the Y-deflection coefficients (in position CAL-calibrated deflection).
SK7	TIME/cm	Step control of the time-coefficients.

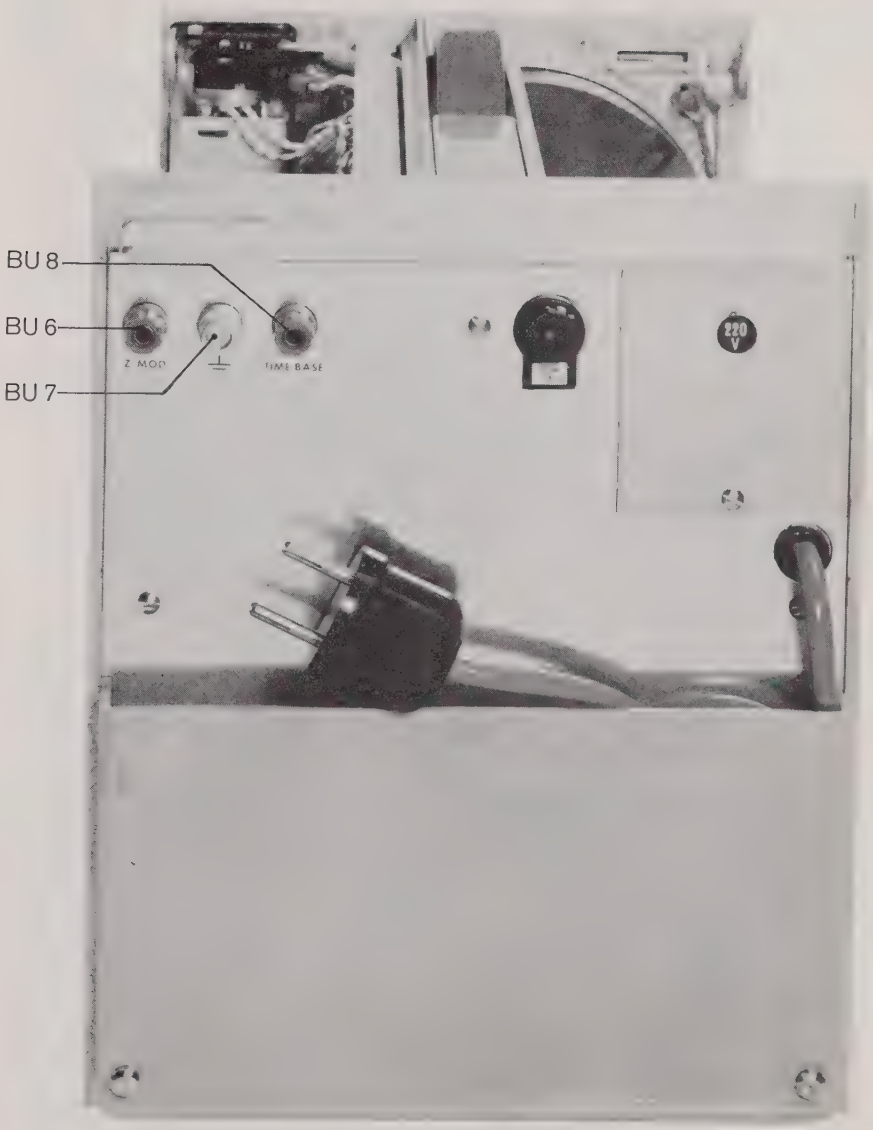


Fig. 5. Rear view

R8/SK8	TIME/cm-CAL	Continuous control of the time-coefficients (in position CAL: calibrated time coefficients).
SK9	TRIGG. +/—	Selection of triggering on positive- or negative-going edge of the trigger signal.
SK10	TRIGG. INT. EXT.	Selection of triggering on an internal voltage or on an external voltage connected to terminal TRIGG.
BU2	1 MΩ - 30 pF	Input of Y-amplifier.
R9/SK11	LEVEL-AUT	Adjustment of the trigger level (in position AUT, a stationary trace is obtained automatically).
BU3	X-EXT	Input of X-amplifier. When switch TIME/cm has been turned fully clockwise, this input can be used to obtain a horizontal deflection by means of an external voltage.
BU4	⏚	Earthing socket
BU5	TRIGG.	External trigger input.
BU6	Z-MOD	Input for brightness modulation.
BU7	⏚	Earthing socket.
BU8	TIME BASE	Output from which the sawtooth voltage, generated in the instrument, is available.

Operation

A. MAKING THE TRACE VISIBLE

1. Preliminary settings

a. Adjusting the time-base stability control

Note: Once set, the stability control seldom requires readjustment

- Set all continuous controls (including STAB) to their mid-positions
- Set switch AC-O-DC to 0
- Set switch $\times 1$-$\times 10$ to $\times 1$
- Set switch MAGN to $\times 1$
- Set switch TIME/cm to 20 msec.
- Set control LEVEL to AUT.

The trace should then be visible on the screen centre
If not:

- Set control INTENS fully anti-clockwise
- Re-adjust DC BAL until the trace is in the centre of the screen

When the trace is visible:

- Re-adjust the control INTENS to prevent damage of the screen
- Set control LEVEL fully anti-clockwise short of position AUT
- Adjust control STAB to the position just anti-clockwise of that at which the trace becomes visible

The stability is then set and the trace can be made visible again either with the LEVEL control adjusted for the signal to be tested or by setting to AUT.

b. Adjusting the d.c. balance

- Make the time-base line visible on the screen
- Set the control Y-SHIFT to mid-position.

- Set switch AC-O-DC to position 0.
- Set switch X1-X10 to position X10.
- Set the trace to the centre of the screen by means of knob DC BAL.
- Turn the continuous attenuator control to and fro between maximum and minimum positions. At the same time, adjust control DC BAL until position variations of the continuous attenuator control no longer cause the trace to leave the centre of the screen.

Note: After the d.c. balance has been adjusted, only control Y-SHIFT should be used to obtain the desired vertical position of the trace.

2. Input circuit

The signal to be displayed should be applied to the Y-input socket. If the signal has a large d.c. component, switch AC-O-DC should be set to position AC so as to avoid the trace from lying outside the range of the Y-shift control.
To facilitate a rapid determination of the zero volts d.c. level, the input switch has been provided with position 0. In this positon, the amplifier input is disconnected from the input socket and earthed.

B. INTERNAL TRIGGERING (automatic)

- Apply the signal to be tested as described in A2.
- Set TRIGG + / — to the desired polarity.
- Set knob LEVEL to position AUT.
- Adjust the trace height with switch V/cm and the relevant continuous control. (The deflection coefficient is calibrated only if the continuous control is in position CAL.)
- Adjust the time coefficient with switch TIME/cm and the relevant continuous control. (The time coefficients are calibrated only if the continuous control is in position CAL.)
- If necessary, the trace can be magnified in the X-direction with knob MAGN.

C. EXTERNAL TRIGGERING

- Apply an external trigger voltage to socket TRIGG. and set switch INT-EXT to position EXT.
- Further, proceed as for internal triggering.

D. TRIGGERING WITH MANUAL TRIGGER LEVEL CONTROL

- Set all knobs as described for A and B.
- Adjust knob LEVEL so that the time base starts at the desired level of the input signal.

E. TRIGGERING ON VIDEO SIGNALS

- Apply the voltage to be tested to the Y-input.
- Set switch + / — to position + if the signal has positive-going syncronising pulses (i.e., a negative video signal) and to the position — if the signal has negative-going synchronising pulses.
- Set switch TIME/cm to position TV LINE if triggering is to take place on the line synchronising pulses and to position TV FRAME if triggering is to take place on the frame synchronising pulses.
- The time coefficient can be controlled with continuous control TIME/cm and switch MAGN.

F. HORIZONTAL DEFLECTION WITH AN EXTERNAL VOLTAGE

- Set switch TIME/cm to position X-EXT.
  The time-base generator is then switched off and blocked.
- The horizontal amplitude can be varied with knob MAGN.

G. BRIGHTNESS MODULATION

The voltage required for brightness modulation should be applied to socket Z-MOD. on the rear of the instrument.

Applications

VI

By means of the PM 3220 and PM 3221, qualitative and quantitative analysis can be carried out on signals as a function of the time or as a function of another signal.
In this chapter, an insight will be given in the possibilities of both instruments with the aid of some technical standards and measuring principles Y-deflection.

AC-O-DC switch

In position DC, the input is coupled directly to the Y-amplifier. Since no coupling capacitors are used, the complete bandwidth of the instrument is available.
This means that input signals are applied completely to the deflection plates without being distorted. This implies that d.c. voltages on the input are displayed on the screen as trace shift.
This may give rise to difficulties when signals are to be displayed which are superimposed on high d.c. voltages. In order to be able to display the a.c. signal in those cases, a strong attenuation would be required, with the result that the a.c. signal would also be attenuated. Position AC has been provided to prevent this.
In this position, a blocking capacitor is connected between the input and the Y-amplifier, with the result that only the a.c. component is applied to the amplifier.
However, as a result of this, not only the d.c. voltage but also the lower frequencies (up to approximately 10 Hz) of the a.c. voltage signal will be suppressed or attenuated.
When square-wave-voltages having low frequencies are displayed, this will result in some pulse droop.
In position O of the AC-O-DC switch, the connection between the input and the Y-amplifier is interrupted and the amplifier input is earthed. In this position, the d.c. balance of the amplifier can be adjusted. This serves to adjust the operating range of the amplifier symmetrically around the earthing level.
It is thus obtained that a signal on the screen can be shifted upwards as much as downward and also that the peaks of a magnified signal can be displayed within the screen without being distorted. The d.c. balance is adjusted as described in point V.A.1b.

Measuring probes

For judging the measuring result, it is of importance to take into account the effect of the input impedance of the oscilloscope on the circuit under test. This impedance, forming a load for the signal source, can in some cases actually influence the voltage to be measured.

At higher frequencies, the input impedance in general is determined by the input capacitance.

When measuring on tuned circuits, it should also be taken into account that the input capacitance may cause detuning.

The load capacitance can be strongly reduced by using a 1 : 10 attenuator probe. By means of this probe, the ohmic as well as the capacitive load is reduced by approximately a factor 10.

Moreover, the use of an attenuator probe offers the advantage that the lowest frequency is reduced by approximately a factor 10 in case of a.c. coupling.

The deflection coefficients of the Y-amplifier also become 10× larger, so that it is possible to display signals having a very high amplitude. However, the maximum permissible voltage on the measuring probe may not be exceeded.

Effect of the impedance of the oscilloscope on the measuring object.

Measuring object	*Impedance of Y-input*	*Effect of*	
		input resistance	*input capacitance*
5 kΩ//30 pF	1 MΩ//30 pF	Negligible	Large.
1 MΩ//0.01 μF	1 MΩ//30 pF	Large (measuring error approx. 50%)	Negligible, especially at high frequencies

Parasitic phenomena

At frequencies higher than some hundreds of kHz, capacitances and selfinductances of cables may start having an effect. Moreover, the measuring set-up will be more sensitive to interference fields on account of the lower voltage values usually prevailing at these frequencies. When measuring on voltage sources having a high internal resistance and a low terminal voltage, it is therefore recommended to measure, if possible, via an attenuator probe or via a 1 : 1 measuring probe or screened cable. Especially avoid double earthing: in the loop thus formed, hum voltages may be introduced.

Voltage measurements

- When measuring voltages, take into account that an oscilloscope does not indicate the r.m.s. value of the voltage (as most valve voltmeters do) but the peak to peak value. Relation $V_{rms} = \frac{V_{p-p}}{2\sqrt{2}} = \frac{V_{p-p}}{2.82}$ applies in case of purely sinusoidal signals.
- The measuring accuracy of $\pm$ 3% applies to the flat part of the amplitude frequency response curve. To ensure a proper square-wave reproduction, the amplitude frequency response curve of every good oscilloscope amplifier starts dropping at approximately one third of the bandwidth.
  This should be taken into account when determining the accuracy of the measurement.

Triggering

If a periodic signal is to be displayed, it is necessary that the X-deflection always starts at a certain point of the wave form. This is to obtain a stationary trace.
The starter of the X-deflection is the trigger unit which is controlled by a signal derived from the Y-input signal. Each time the input signal passes a certain level of the wave form in positive or in negative direction, the trigger unit supplies a pulse starting the time-base generator. From this it follows that the X-deflection sarts when he input signal passes through that level (the trigger level) of its wave form, with the result that a stationary trace is obained.

Automatic triggering

The automatic triggering is most often used on account of its simple operation. In this position it is possible to display a large number of wave forms having different amplitude and shape without it being necessary to operate any of the trigger controls.
If no trigger signal is present, a time base line remains visible on the screen which is useful for reference purposes.
With this trigger mode, the trigger level is adjusted automatically to the average value of the trigger signal.
By means of the + /— switch, triggering can be adjusted to the positive-going or negative-going edge of the input signal.
The automatic trigger position can be used for practically any signal.

Trigger level

In case of complicated signals in which a number of non-identical voltage shapes occur periodically, the time axis should always be started with the same voltage shape so as to obtain a stationary trace.
This is possible when one of the details has a deviating amplitude.
By means of knob LEVEL, the trigger level can then be adjusted so that only this larger voltage variation passes this level.
Also in the case of observing a leading edge (with PM 3221), it is useful to use the LEVEL setting.
The trigger level can then be adjusted so that the time base is started already at the beginning of this leading edge.

External triggering

External triggering is applied for signals having a strongly varying amplitude, if a signal having a fixed amplitude and equal frequency is present.
This removes the necessity of readjusting the level control at every variation of the input signal.

TV LINE and TV FRAME

To simplify triggering on television signals, a synchronisation separator is switched on in the two TV positions of the tme-base switch. This separates the synchronising pulses from the trigger signal. The line and frame synchronising pulses are separated from each other by an integrator.
In position TV LINE, the line pulse is used to start the time-base generator. In position TV FRAME, the frame pulse is used to do this. In these positions, the time coefficient of the time-base generator can be adjusted with continuous control TIME/cm.
As is known, the synchronising signals have a polarity opposite to that of the video signal.
When triggering is to take place on a positive video signal, the trigger polarity switch should therefore be in position –. For a negative video signal, it should be in position +.

Delay line

The input signal is also used to trigger the time-base generator. For this, the signal is applied to the trigger unit which converts it into trigger

pulses. However, it does require some time for the trigger unit to start the X-deflection.
During this time, the first part of the input signal that has already reached the deflection plates, may already have passed completely or in part. This implies that a steep leading edge will not be displayed on the screen. To avoid this, a delay line has been incorporated in the Y-amplifier of the PM 3221. The trigger signal is taken off between the input and the delay line.
If the delay time of the line is selected slightly longer than the time required by the trigger unit to start the X-deflection, the time base will start running before the leading edge of the input signal has reached the deflection plates. Consequently, the leading edge will also be displayed on the screen. For triggering, it is recommended to use the level setting because in that case the time base can be started at any desired point of the leading edge. In this way, full benefit is derived from the advantages of the delay line.

Hints for measuring rise times

- The rise time is defined as the time required by the rising edge of a signal to rise from 10% of its peak value to 90% of its peak value.
- Due to the delay line it is also possible in the PM 3221 to measure the rise time of pulses having a low repetition frequency.
- If the rise time of the oscilloscope is approximately that of the object to be measured, it should be calculated in accordance to the following equation:

$$Tw = \sqrt{T^2m - T^2o}$$

in which: Tw = actual rise time
Tm = rise time measured
To = rise time of the oscilloscope

External X-deflection

The time-base generator is switched off when the time base switch is turned fully counter-clockwise. X-deflection can then be obtained by applying an external signal to the X-input.
In this way the oscilloscope can be used to some extent as an X-Y oscilloscope. The limitation is formed by the fact that the X and Y-amplifier are not identical and that therefore phase differences will arise between the X and Y channels at higher frequencies.

Brightness modulation

To insert additional information into the oscillogram, the trace can be brightness modulated by means of external voltage.
This can be obtained by applying the external signal to socket Z-MOD on the rear of the instrument.
In this way very accurate time measurements can be carried out in the oscillogram if the brightness is modulated with time markers. The measurements can then be carried out directly with the aid of the time markers in the picture.

Photographing oscillograms

With the aid of PHILIPS photographic equipment PM 9300, photographs can be taken of oscillograms.
The PM 9300 includes, amongst others, a Rolleicord camera, a Polaroid Land cassette and various adapters for oscilloscopes having various screen diameters. The 13 cm adapter can be mounted on the PM 3220 or PM 3221 after removing the upper text plate. For further details concerning recording materials, exposures, time coefficients, etc., please consult PHILIPS publication: PHOTOGRAPHIC RECORDING.

SERVICE NOTES

Circuit description

VII

A. Y-AMPLIFIER

The Y-amplifier is a d.c. amplifier consisting of four sections, i.e.:
- an input attenuator
- an input stage consisting of cathode follower B1
- a pre-amplifier formed by the push/pull-connected amplifier stages TS1-TS3 and TS9-TS11 and the six emitter followers TS6, TS7, TS8, TS10, TS12 and TS13.
- an output amplifier consisting of push/pull amplifier B2′-B3′ and cathode followers B2″ and B3″.

1. Input attenuator

The deflection coefficient of the amplifier can be increased by switching on a high-ohmic attenuator in the input circuit. This attenuator consists of five sections providing an attenuation of:

10 × (R16-R17)
100 × (R18-R19)
1000 × (R21-R22)
2 × (R24-R26)
5 × (R27-R28)

By means of switch SK6 the attenuator sections can be combined so that eleven deflection coefficients can be selected. These sections are frequency compensated by means of trimmers C19, C24, C29, C32, C34, C36 and C38. Trimmers C18, C23 and C28 have been adjusted so that the input capacitance is the same in all attenuator positions. By means of switch SK4, the input socket BU2 can be connected directly (DC) or via an isolating capacitor (AC) to the attenuator. In position 0 of switch SK4, the input of the Y-amplifier is earthed and the connection with BU2 is cut off. In this position the zero level of the amplifier can be checked.

2. Input stage

To obtain a high input impedance of the amplifier, a cathode follower stage has been used (B1′).
The d.c. drift of the amplifier has been reduced by cathode follower B1″ because variations in the d.c. levels on the cathodes of B1′ and B1″ neutralise each other.
The d.c. voltage on the control grid of B1″ (adjustable by means of R4, DC-BAL.) serves to equalise the emitter d.c. voltages of TS1 and TS2 when no input signal is connected. There will not be a d.c. voltage across the continuous amplification control R7, with the result that it is prevented that the time base line is shifted across the screen when R7 is turned.

3. Pre-amplifier

The first part of the pre-amplifier is formed by a "Cherry and Hooper" circuit with transistors TS1-TS3 and TS2-TS4.
The "Cherry and Hooper" circuit is an amplifier circuit with current and voltage feedback. The current feedback, obtained by means of the resistors in the emitter circuit of TS1 and TS2, provides the circuit with a high input impedance. The voltage feedback, effected by resistors R52 and R57, provides the circuits with a low output impedance. The circuit offers the advantage of a large bandwidth which is due to, amongst others, the fact that the feedback capacitance of the first transistor almost has no effect.
The amplification is determined mainly by resistors R52 and R57 and the emitter resistor of TS1 and TS2. This resistance and therefore the amplification, can be varied continuously by means of R7.
Capacitor C48 in the emitter circuit renders the feedback dependent from the frequency which benefits the higher frequencies. Resistor R49 prevents distortion in case of deflection up to three times the screen height.
The trace can be shifted across the screen in the vertical direction by means of potentiometer R6 which controls the d.c. potentials on junctions R52-R53 and R54-R57.
The "Cherry and Hooper" circuit is followed by an impedance transformer consisting of emitter followers TS6 and TS7 and which serves to match the input impedance of the push/pull circuit TS9-TS11 to the output impedance of the preceding circuit. Potentiometer R73 is used to adjust the sensitivity of the Y-amplifier.

Swich SK5 is included in push/pull stage TS9-TS11. By means of this switch, the circuit can be connected in parallel to the emitter resistors of TS9 and TS11 by means of potentiometer R71. As a result, the amplification of this stage will increase by a factor 10. Due to this the input sensitivity of the Y-amplifier becomes 10× as large in all positions of the step attenuator.
The control range of potentiometer R6 (Y-SHIFT) is adapted to this higher amplification by connecting resistor R58 in parallel to it.
The trigger signal is also taken from this stage and applied, via emitter followers TS8 and TS10, to the trigger amplifier.
In the PM 3220, push/pull circuit TS9-TS11 is connected to the output amplifier via emitter followers TS12 and TS13.
In the PM 3221, this coupling is effected via a delay line and emitter followers TS12 and TS13.
This delay line has been incorporated so as to enable the display of the leading edge of fast phenomena on the screen. Network R74-C49 compensates for the cable losses. Networks L1-R81 and L2-R92 serve for the proper termination of the delay line.
Emitter followers TS12 and TS13 serve to reduce the effect of the input capacitance of B2′ and B3′ on push/pull amplifier TS9-TS11.

4. Output amplifier

In view of the high voltages required for the deflection of an electron beam, electron valves have been applied in the output amplifier.
Push/pull amplifier B2′-B3′ is driven symmetrically and is connected to the Y-deflection plates of the cathode ray tube via cathode followers B2″ and B3″. Both cathode followers serve to reduce the effect of the capacitances of the deflection plates on the anode circuits of B2′ and B3′.
Valves B2″ and B3″ are protected against positive grid voltages, occurring immediately after the instrument is switched on, by diodes GR3 and GR4.

B. TIME-BASE GENERATOR

This consists of a Bootstrap integrator (TS509) controlled by a Schmitt trigger (TS506-TS507). For the description of its working, the following initial condition of the Schmitt trigger is assumed.
TS506 not conductive
TS 507 conductive

The collector voltage of TS507 and with it the base voltage of TS508, will then be only slightly negative, so that TS508 carries little current. Consequently, the emitter potential of TS509 is little negative also. As a result of this, diode GR502 is conductive, so that the emitter level of TS508 also determines the base level of TS509.

This level has been selected so that Bootstrap integrator TS509 is blocked. If a negative pulse is then applied to the base of TS5, the Schmitt trigger will reverse to condition:

TS506 conductive

TS507 not conductive

The collector voltage of TS507 and with it the base voltage of TS508, will then be strongly negative, so that TS508 carries much current.

As a result, the emitter potential of TS508 is also low.

Due to this, diode GR502 is blocked, with the result that the blocking of the Bootstrap integrator is eliminated.

The time-base capacitor C_1 (C528 . . . C537) is then charged at a constant current, so that a linearly increasing negative-going voltage arises across this capacitor.

This voltage is returned to Schmitt trigger TS506-TS507 via emitter follower TS511, phase inverter TS512 and emitter follower TS513. The Schmitt trigger will reverse to condition:

TS506 not conductive

TS507 conductive

when the linearly increasing voltage has attained a certain level.

As a result, the Bootstrap integrator is blocked again until the next trigger pulse appears.

The constant charging current is obtained by means of feedback in the Bootstrap integrator, with the result that the voltage across $R536 + R8 + R_1$ (= R591, R593, R594, R596, R597 respectively) is kept constant.

This feedback is effected via TS511 and GR503.

Emitter follower TS511 ensures a high impedance on the base of TS509. The base current of TS509, which is not constant, will therefore be small with respect to the charging current of the time-base capacitors. As a result, a very good linearity of the sawtooth voltage is obtained. The charging current of the time-base capacitor and with it the time coefficient, can be adjusted accurately by means of R536.

The stability of the time-base generator can be controlled with potentiometer R5 (STAB.). This potentiometer determines the value of the d.c. voltage on the base of TS506. This d.c. voltage is selected so that the

negative pulse, arising at the base of TS506 at the end of the flyback, cannot reverse the Schmitt trigger.
In the feedback circuit, in the collector lead of the phase inverter stage TS512, amplitude control R546 is included.
The feedback circuit also includes hold off capacitors Cho (C538 . . . C546) which ensure that the time-base capacitors can be discharged completely after the scan. Consequently, the sawtooth voltage always starts at the same level.
By means of switch SK7, twenty-one different time coefficients can be selected by switching on various capacitors and charging resistors. The charging voltage and consequently the time coefficient, can be varied continuously with R8.
In positions TV LINE and TV FRAME, the control range of R8 has been increased from 1 : 3 to 1 : 5 with the aid of R541. The time coefficient is calibrated when R8 is turned clockwise.
The sawtooth voltage is taken from the emitter of TS511 and applied to the X-amplifier (via SK7-IV-A) and to output terminal BU8 (TIME BASE).

C. BEAM DEFLECTION

To make sure that the electron beam is not displayed on the screen during the flyback, such a voltage is applied to g5 of the cathode ray tube so that blanking occurs.
The voltage required for this is delivered by the bi-stable multivibrator TS518-TS519 and it is applied to the cathode ray tube via emitter follower TS520.
The moment at which this multivibrator switches is determined by the positive voltage transient occurring on the emitter of TS505 during the flyback.
On account of this voltage transient, the multivibrator assumes the position:
TS519 not conductive
TS518 conductive
The collector voltage of TS518 is therefore low and also the output voltage of TS520. The voltage difference between electrodes $_{G}2$ and $_{G}3$ of the cathode ray tube is then large.
As a result, the desired beam deflection occurs.
At the beginning of the scan of the sawtooth voltage, the negative voltage

transient occurring on the emitter of TS505 will reverse the multivibrator to position:
TS519 conductive
TS518 not conductive
The voltage difference between g2 and g3 of the cathode ray tube then decreases to zero volts and the electron beam will be displayed again.

D. TRIGGER PULSE SHAPER

This consists of the following sections:
– an amplifier stage (TS501-TS502)
– a Schmitt trigger (TS503-TS504)
– a synchronisation separator (TS509)
The trigger signal can be taken, at option, from the Y-amplifier or from an external source.

– Amplifier stage

This is an emitter coupled push/pull amplifier. The trigger signal is applied to the base of TS501 via capacitor C502. As a result, voltages having the same amplitude but being counter-phased, arise on the collectors of TS501 and TS502. By selecting one of these voltages with switch SK9 (+/—), it is possible to trigger on the positive-going or on the negative-going edge of the signal.
The d.c. voltage on the base of TS502 can be continuously adjusted by means of potentiometer R9 (LEVEL).
Depending on this setting, since the amplifier is overdriven, a different part of the signal is amplified each time. The trigger level is therefore determined by the position of R9.

– Schmitt trigger

Switch SK11 closed (position LEVEL).
The amplified trigger signal reverses Schmitt trigger TS503-TS504. In case of a repetitious trigger signal, a square-wave voltage having a constant amplitude then arises on the collector of TS4.
This voltage is differentiated to positive and negative spikes by C507 and R522. The positive pulses are short-circuited by diode GR501. The negative pulses are applied to the time-base generator.
Switch SK11 open (position AUT).

In this position of SK11, capacitor C504 is included in the base circuit of TS503. As a result, the Schmitt trigger is circuited as an astable multivibrator, with the result that a periodic LF square-wave voltage arises on the collector of TS504. The time-base generator will therefore be started normally without a trigger signal being applied to the trigger pulse shaper.
If there is a trigger signal present, the astable multivibrator will be synchronised by this voltage and it will deliver trigger pulses in the rhythm of the input voltage.

– **Synchronisation separator**

In positions TV LINE and TV FRAME of switch SK7, synchronisation separator TS514 is switched on. As a result, it is possible to trigger on the line and frame synchronising pulses of a television signal.
The video signal is applied to synchronisation separator TS514 via amplifier stage TS516. Transistor TS514 is set so that peak detection is effected by the base emitter diode and only the peaks of the synchronising pulses will fall in the range of operation.
The line and frame synchronising pulses are separated from each other by integrator R562-C516.
In position TV LINE, the line synchronising pulses are applied to Schmitt trigger TS503-TS504 via amplifier stage TS517. In position TV FRAME, the frame synchronising pulses are applied to the Schmitt trigger via amplifier stage TS517.

E. X-AMPLIFIER

This is a push/pull amplifier consisting of valves B701 and B702. The feedback of this amplifier and therefore the deflection sensitivity in X-direction, can be adjusted with R712 and R713.
By means of switch SK2 (MAGN.) various resistors can be connected in parallel to the cathode circuit, with the result that it is possible to choose from three deflection coefficients.
With potentiometer R3 (X-SHIFT) the d.c. level on the control grid of valve B702 can be varied, with the result that the picture is shifted in the horizontal direction.
In position X-EXT. of switch SK7, the connection between the time-base generator and the X-amplifier is cut off.
It is then possible to apply an external signal to the X-amplifier via connection terminal BU3.

To prevent cross-talk of the time-base voltage on the X-amplifier, the time-base generator is switched off in this position of SK7 by applying a negative voltage to Schmitt trigger TS506-TS507.
Moreover, a negative voltage is applied to the base of TS518 so that the beam deflection multivibrator always is in condition: TS518 not conductive, TS519 conductive, so that unblanking is ensured.

F. CATHODE RAY TUBE CIRCUIT

The intensity of the trace can be controlled with potentiometer R1 (INTENS). The control range is determined by choice resistors R308 and R309. The intensity voltage is stabilised by valves B302 and B303.
Focusing is effected with potentiometer R2 (FOCUS) while the astigmatism of the electrostatic lens can be corrected with R312.
Barrel and cushion distortion can be corrected with potentiometer R313.
With switch SK3 (ILLUM), the graticule illumination can be adjusted in three steps.
Via socket BU6 (Z-MOD), the picture can be brightness modulated.

G. SUPPLY SECTION

– 16 V

The a.c. voltage across winding S2 of the supply transformer is full-wave rectified and subsequently stabilised electronically. This is effected by comparing a voltage proportional to the output voltage, via a difference amplifier (TS1003-TS1004) to a reference voltage (GR1011). Any difference is amplified and fed back via a series regulator (TS1001). Emitter follower TS1002 ensures current amplification between the difference amplifier and the series regulator.
The output voltage can be coarsely adjusted with R1016 and fine adjusted with R1018.
The ripple voltage present on the output is fed back via C1007. By means of R1014, the value of the fed back voltage can be adjusted and the ripple voltage can thus be adjusted to minimum.

– 80 V

To obtain this voltage, the a.c. voltage on winding S4 of the supply transformer is full-wave rectified and smoothed.

+ 95 V and + 200 V

The a.c. voltage across winding S3 is full-wave rectified and then stabilised electronically at +95 V. This is effected in a similar way as was the case with the — 16 V voltage.
The reference voltage is delivered by valve B1002 while a single amplifier stage (B1001) is applied as a comparison stage.
The output voltage can be adjusted with R1011. The ripple voltage is fed back via C1002 and can be adjusted to minimum by means of R1004.
Via smoothing filter R1002-C1003, the voltage of +200 V is taken off.

Post-acceleration and calibration voltage

This voltage is generated with an oscillator formed by transistor TS1101 and the primary of the high voltage transformer. Across the secondary, a high a.c. voltage arises which is rectified to + and — 1500 V by means of diodes GR1101 . . . GR1104.
The calibration voltage is also obtained from the primary of the transformer.
The calibration voltage is kept constant by Zener diode GR1106 and adjusted to exactly 5 V_{p-p} with choice resistor R1107.

Gaining access to the parts

VIII

Caution!

Very high voltages are generated in this instrument so that great care must be taken when carrying out work inside the instrument.

A. REMOVING THE SIDE PANELS

The apparatus has one plate on each side, each fixed by means of two quick fasteners SB (Fig. 14). Loosen these fasteners and remove the panels from the frame.

B. REMOVING THE KNOBS (Fig. 6)

Single knobs

- Remove cap A.
- Loosen screw B.
- Pull the knob off the spindle.

Double knobs

- Remove cap A.
- Remove screw B.
- Remove the inner knob.
- Loosen nut C.
- Pull the outer knob off the spindle.

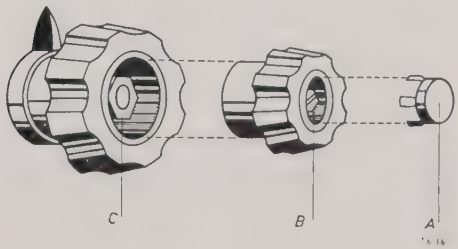


Fig. 6. Removing the knobs

C. REMOVING THE BEZEL, TEXT PLATE, GRATICULE AND CONTRAST PLATE

- Press pin A (Fig. 4) upwards.
- The text plate and the bezel can then be taken out of the frame. The graticule and the contrast plate are then accessible.

D. GAINING ACCESS TO THE HIGH VOLTAGE UNIT (Fig. 7)

- Place the instrument on its side.
- Loosen screw S a few turns.
- Slide the small bottom plate out of the instrument.

The high voltage unit can then be slid out for servicing (take care that the connection wires are not damaged), so that measurements can be carried out while the instrument is switched on.

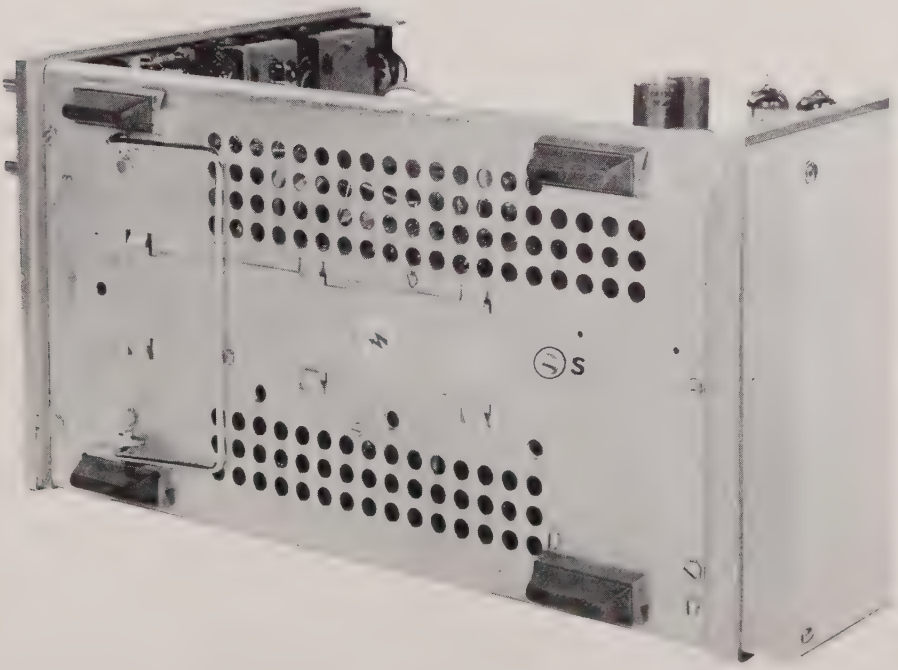


Fig. 7. Bottom view with high tension unit

Maintenance

– **Segment switches**

Should these switches no longer function properly on account of soiling, they may be treated with switch oil (see MECHANICAL PARTS, chapter XIV). This oil has cleaning and lubricating properties.
After treatment with this oil, set the switch to all its positions a few times.

– **Cabinet panels**

If the cabinet panels (coated with polyvinylchloride) have become dirty, they may be cleaned with soap and water after having been removed (see chapter VIII); if necessary, a scouring agent may be used.

Adjusting elements and their functions

The order given below is arbitrary. For the complete adjusting procedure, the order of chapter XI is recommended

Adjustment	*Element*	*Fig.*	*Measuring instrument*	*Recommended PHILIPS type*	*Chapter XI point*
Supply					
1. — 16 V	R1016, R1018	9	d.c. valve voltmeter	GM 6020	B
			Oscilloscope	PM 3220	
ripple	R1014	9	Variable transformer	E401AB/010	B
2. +95 V	R1011	9			
ripple	R1004	9			
Cathode ray tube circuit					
1. intensity	R308, R309	9	—	—	C1
2. barrel and cushion distortion	R313	9	—	—	C2
3. Focus and astigmatism	R307, R312	9	—	—	C3
Y-amplifier					
1. d.c. balance	R38	8	—	—	D1
2. Sensitivity	R71, R73	8	L.F. Generator	PM 5120	D2
			Variable transformer	E401AB/010	
3. Square-wave reproduction	C18, 19, 23, 24, 28, 29, 32, 34, 36, 38, 48	8	Square-wave generator	GM 2324	D4
Only for PM 3221	R74	8			
Calibration voltage					
	R1106, R1107	24	Oscilloscope with calibrated deflection	PM 3220	E
X-amplifier					
Sensitivity	R712- R713	9	L.F. Generator	PM 5120	F1
Time-base generator					
1. Stability	R5	4	R.F. Generator	PM 5300	G1
2. Time coefficients	R536, 546, 595	9	L.F. Generator	PM 5120	G3

Checking and adjusting

XI

A. GENERAL INFORMATION

The tolerances given below are factory tolerances which apply only when the instrument is readjusted.
They may deviate from the data given under I.
All adjusting elements, their functions and their positions, are given in the table of chapter X.

B. SUPPLY

Mains current

Check that the mains voltage adapter is set to 220 V and connect the instrument to this voltage (50 Hz).
The current taken from the mains may not exceed 400 mA.

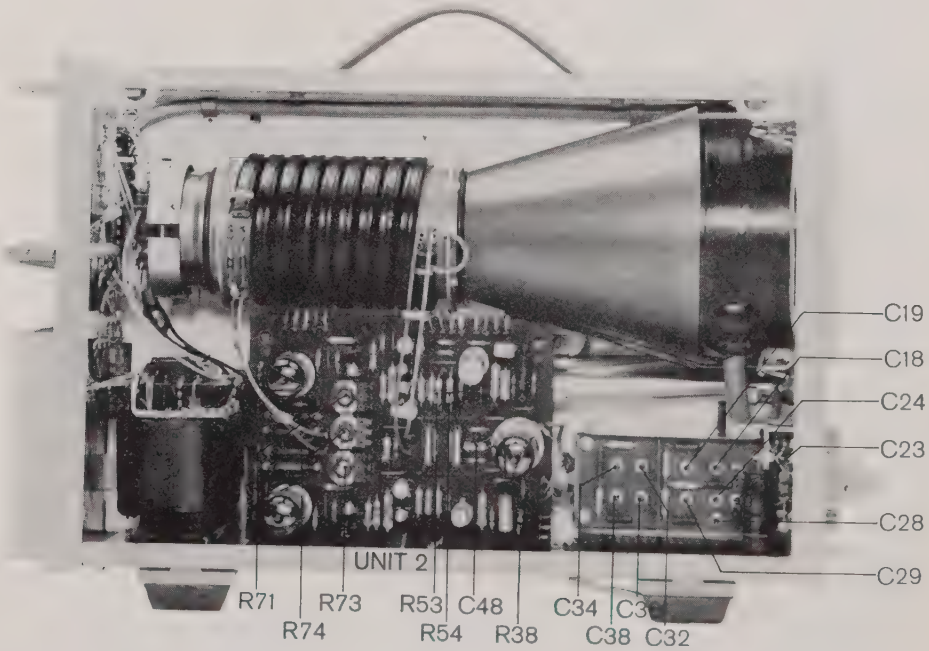


Fig. 8. Side view (left)

—16 V

- Set switch TIME/cm (SK7) to position X-EXT.
- Measure the voltage on junction R1022/cTS1004.
  This should be —16 V. If this is not so, it is possible to adjust to exactly —16 V by means of potentiometer R1018.
  If necessary, select a different value for R1016.
- By means of R1014, adjust the ripple voltage on the —16 V d.c. voltage to minimum.
- Vary the a.c. voltage to which the instrument is connected between 198 and 242 V with the aid of a variable transformer.
  The —16 V d.c. voltage may not vary more than 100 mV.
  The ripple voltage may not exceed 10 mV_{p-p}.

+95 V

- Measure the voltage on junction R1004/R1008.
  This should be +95 V, + or —1 V. If necessary, select a different value for R1011.

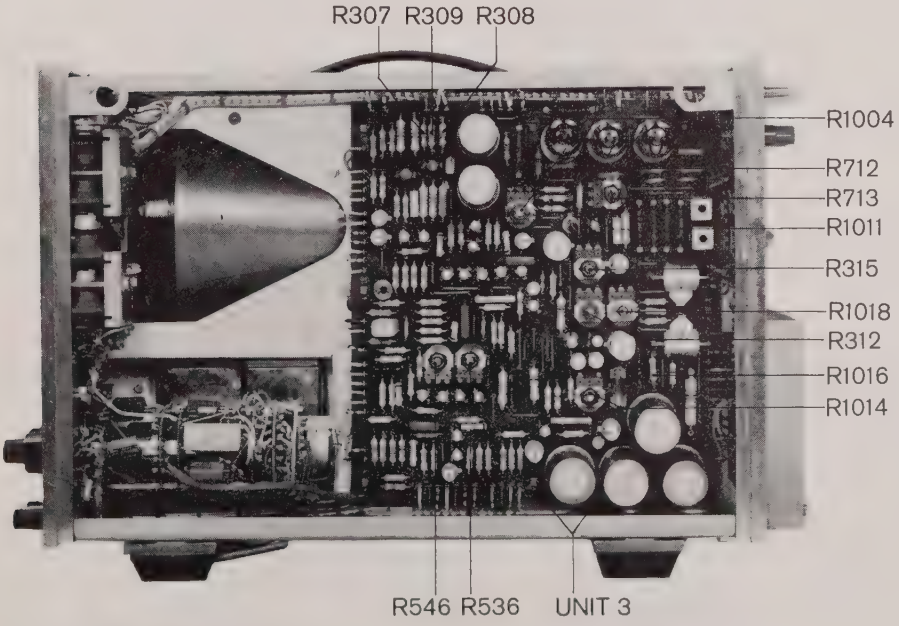


Fig. 9. Side view (right)

- Adjust for minimum ripple voltage by means of R1004.
- By means of a variable transformer, vary the a.c. voltage to which the instrument is connected between 198 V and 242 V.
  The + 95 V d.c. voltage may not vary more than 100 mV.
  The ripple may not exceed 20 mV_{p-p}.

—80 V and + 200 V

- Measure the voltage across C1006
  This should be —80 V, + or —5 V.
- Measure the ripple voltage across C1006. This may not exceed 0.2 V_{p-p}.
- Measure the voltage across C1003.
  This should be 200 V, + or —10 V.
- Measure the ripple voltage across C1003. This may not exceed 2 V_{p-p}.

High voltage

- Turn INTENS (R1) fully counter-clockwise.
- Measure the voltage across C1108. This should be + 1400 . . . + 1500 V.
- Vary the a.c. voltage to which the instrument is connected between 198 and 242 V.
  The d.c. voltage across C1108 may not vary more than 15 V.
- Measure the ripple voltage across C1108. This may not exceed 1 V_{p-p}.
- Measure the voltage across C1107. This should be —1400 . . . —1500 V.
- Vary the a.c. voltage to which the instrument is connected between 198 and 242 V.
  The ripple voltage may not exceed 1 V_{p-p}.

C. THE CATHODE RAY TUBE CIRCUIT

1. Intensity

- Set LEVEL (R9) to position AUT.
- Set TIME/cm (SK7) to position 1 msec/cm.
- Turn INTENS (R1) from minimum intensity clockwise over a third of its control range and select such a value for R308 that a trace is just displayed.
- Turn INTENS (R1) clockwise and select such a value for R309 that

the trace is magnified slightly (maximum 2 mm).
- Repeat both adjustments.

2. Barrel and cushion distortion

- Set the trace to the centre of the screen with X-SHIFT (R3) and Y-SHIFT (R6).
- Set V/cm (R7) to position CAL.
- Set V/cm (SK6) to position 1 V/cm.
- Apply a sinusoidal voltage having a frequency of 2 kHz and such an amplitude that the trace height is 4 cm to socket 1 MΩ//30 pF (BU 2).
- Set V/cm (SK6) to position .1 V/cm.
- Set potentiometer R313 so that the vertical lines on the screen are as straight as possible.
- Set TIME/cm (SK7) to position X-EXT.
- Apply voltages having frequencies of 50 Hz and 10 kHz and amplitudes so that a square of 6 × 10 cm is obtained to inputs 1 MΩ//30 pF (BU2) and X-EXT (BU3) respectively.
- Check that no point of the sides of the square falls within a concentric square of 5.8 × 9.7 cm.

3. Focus and astigmatism

- Set TIME/cm (SK7) to 0.5 msec.
- Apply a 2 kHz sine-wave voltage to socket 1 MΩ//30 pF (BU 2) and adjust the picture height to 8 cm symmetrically around the screen centre.
- Adjust for a sharp trace with FOCUS (R2) and potentiometer R312 at normal brightness. After adjustment R2 should approximately be in mid-position.
  If necessary select a different value for R307.

D. Y-AMPLIFIER

1. D.C. Balance

- Set AC-O-DC (SK4) to 0.
- Set X1-X10 (SK5) to X1.
- Set V/cm (SK6) to 10 mV/cm.
- Set DC BAL (R4) to mid-position.
- Set LEVEL (R9) to AUT.
- With Y-SHIFT (R6) place the time-base line in the centre of the screen.

- Adjust DC BAL (R4) so that the time-base line does not shift when V/cm (R7) is rotated.
  DC BAL (R4) should now approximately be in the middle of its control range. If necessary select a different value for R38.
- Set X1-X10 (SK5) to X10 and adjust the d.c. balance another time. With Y-SHIFT (R6) keep the time base line in the centre of the screen.
- Switch SK5 from X10 to X1; the time-base line should not shift more then 1 cm.
  If necessary mount a resistor in parallel to R53 or R54.
- Set AC-O-DC (SK4) to position DC.
- Short-circuit socket 1 MΩ//30 pF (BU2) to earth.
  The time-base line should not shift more than 2 mm.

2. Sensitivity

- Set V/cm (R7) to position CAL.
- Apply a voltage of 80 mV_{p-p}, frequency 2 kHz, to socket 1 MΩ//30 pF (BU2).
- Adjust R73 so that the trace height is 8 cm.
  After the adjustment, R73 should still have some control reserve. Tolerance at final check: 1%. If necessary, readjust R73.
- Vary the a.c. voltage to which the instrument is connected between 198 and 242 V.
  The trace height may not vary more than 3.5% and the trace may not shift more than 0.5 cm in the vertical direction.
- Set X1-X10 (SK5) to position X10 and decrease the output voltage by a factor 10.
- Adjust R71 so that the trace height is 8 cm.
  After adjusting, R71 should still have some control reserve left. Tolerance with final check: 1%. If necessary, readjust R71.
- Check the deflection coefficient in all positions of X1-X10 (SK5) and V/cm (SK6) by continually applying the proper voltages having a frequency of 2 kHz.
  The trace height should always be 8 cm, + or —2.5%.

  Tolerance with final check: 3%. When R71 and R73 have been readjusted 2.5%.
- Display a trace having a height of 8 cm.
- Starting from the CAL position, turn V/cm (R7) fully counter-clockwise.
  The trace height should then be between 3 and 2 cm.

3. Hum and noise

- Set X1-X10 (SK5) to position X10.
- Set V/cm (SK6) to position 10 mV/cm and V/cm (R7) to position CAL.
- With open input, the trace height may not exceed 2 mm.
  With this measurement, the cabinet panels should be fitted.

4. Square-wave response

- Set X1-X10 (SK5) to position X1.
- Apply a square-wave voltage of 80 mV_{p-p}, frequency 500 kHz, rise time approximately 10 ns to socket 1 MΩ//30 pF (BU2).
- Select such a value for C48 that just no overshoot occurs.
- Only for PM 3221: adjust to optimum square-wave reproduction by means of potentiometer R74.
- Apply a square-wave voltage having a frequency of 2 kHz and a rise time of 25 ns to socket 1 MΩ//30 pF (BU2).
- At a trace height of 8 cm, adjust the relevant trimmers (see table) so that just no overshoot occurs.

Attenuator position	*Trimmer*
20 mV/cm	C34
50 mV/cm	C38
100 mV/cm	C19
200 mV/cm	C32
500 mV/cm	C36
1 V/cm	C24
10 V/cm	C29

Fig. 10. Square-wave reproduction

- Check the square-wave response in attenuator positions 2, 5 and 20 V/cm at a trace height of 8 cm.
- Set X1-X10 (SK5) to position X10.
- Check the square-wave response in attenuator positions 1, 2 and 5 mV/cm at a trace height of 8 cm.
- Connect an attenuator having an attenuation of 1 : 10 to socket 1 MΩ//30 pF (BU2). This attenuator may consist of a resistor of 9 MΩ, to which a trimmer has been connected in parallel.
- Set V/cm (SK6) to position 10 mV/cm.
- Set X1-X10 to position X1.
- Apply a square-wave voltage having a value of 800 mV_{p-p} and a frequency of 2 kHz to the auxiliary attenuator.
- Adjust to optimum square-wave response by means of the trimmer in the auxiliary attenuator (Fig. 10). Permissible overshoot: 2%.
- In attenuator positions 100 mV/cm, 1 V/cm and 10 V/cm, adjust to optimum square-wave response at a trace height of 8 cm by means of trimmers C18, C23 and C28.
- Set X1-X10 to position X10.
- Check the square-wave response in attenuator positions 20 mV/cm and 50 mV/cm at a trace height of 8 cm.

5. Frequency response

- Set V/cm (SK6) to position 10 mV/cm.
- Set X1-X10 in succession to positions X1 and X10.
- Check the frequency response at a trace height of 8 cm.

SK5 in position X1	SK5 in position X10
2 kHz 8 cm	2 kHz 8 cm
10 MHz $\geqslant$ 5.6 cm	2 MHz $\geqslant$ 5.6 cm

If necessary, repeat point 4.

- In position AC of AC-O-DC (SK4), check that a d.c. voltage connected to the input socket is blocked by capacitor C16.

6. Shift and deflection

- Set X1-X10 (SK5) to position X1.
- Set V/cm (SK6) to position 100 mV/cm.
- Set TIME/cm (R8) to position CAL.
- Check the adjustment of the d.c. balance (point 1).
- Apply a sinusoidal voltage having a frequency of 2 kHz and such an amplitude that the trace height is 2.4 cm, to socket 1 MΩ//30 pF (BU2).

- Set V/cm (SK6) to position 10 mV/cm.
- Check that it is possible to display the peaks of the signal undistortedly within the screen by means of Y-SHIFT (R6).
- Apply a sinusoidal voltage having a frequency of 10 MHz and such an amplitude that the trace height is 3 cm, to socket 7 MΩ//30 pF (BU2).
- Double the input voltage and check that the deflection is 6 cm, + or —0.5 cm.
  If necessary, repeat C5 and the first six points of C4.

7. Microphony

- Set AC-O-DC (SK4) to position 0.
- Set X1-X10 (SK5) to position X10.
- Check that the microphony, which may occur when TIME/cm is switched over, causes a deflection of less than 5 mm. If necessary, replace valve B1.

E. CALIBRATION VOLTAGE (carry out this check when the instrument has attained operating temperature)

- Set AC-O-DC (SK4) to position DC.
- Set X1-X10 (SK5) to position X1.
- Set V/cm (SK6) to position 1 V/cm.
- Set V/cm (R7) to position CAL.
- Connect socket CAL. 5 V (BU1) to socket 7 MΩ//30 pF (BU2). The trace height should then be 5 cm. If necessary, select a different value for R1107 or R1106.
  Tolerance at final check: + or —1%.
- Check the frequency of the calibration voltage.
  This should be 7 . . . 9 kHz.

F. X-AMPLIFIER

1. Sensitivity

- Set TIME/cm (SK7) to position X-EXT.
- Set MAGN (SK2) to position X1.
- Set potentiometer R713 to its mid position.
- Apply a sinusoidal voltage of 8 V_{p-p} having a frequency of 2 kHz to terminal X-EXT (BU3).

– Check that the trace width is 8 cm.
  If necessary, correct with R713 (fine) and R712 (coarse).
  Tolerance at final check: + or —1 %.

2. Square-wave and frequency response

– Apply the external time base voltage to socket 1 MΩ//30 pF.
– Apply a square-wave voltage of 8 V_{p-p}, frequency 100 kHz to socket X-EXT (BU3).
– Adjust for optimum square-wave response by means of C702.
– Check the frequency response at a trace width of 8 cm.
  2 kHz 8 cm
  1.5 MHz $\geqslant$ 5.6 cm

G. TIME-BASE GENERATOR

1. Stability

– Set LEVEL (R9) to position AUT.
– Set + /— (SK9) to position +.
– Set TIME/cm (R8) to position CAL.
– Apply a voltage having a frequency of 1 MHz and such an amplitude that the trace height is 4 mm to socket 1 MΩ//30 pF (BU2).
– Adjust potentiometer STAB (R5) so that a triggered display is obtained.

2. Triggering

a. Internal

– Set INT-EXT (SK10) to position INT.
– Apply a sinusoidal voltage having a frequency of 2 kHz and such an amplitude that, after the correct adjustment of LEVEL (R9), a triggered display is obtained with a trace height of 4 mm, to socket 1 MΩ//30 pF (BU2).
– Check that a triggered trace is also obtained at frequencies of 10 Hz and 2 MHz.
– Check, at a trace height of 2 cm and frequencies of 5 Hz and 10 MHz, that a triggered trace is obtained.
– Set + /— (SK9) to position —.
  The trace should then be triggered on the negative-going edge of the signal. If necessary, readjust LEVEL (R9).

- Adjust a triggered display with a trace height of 8 cm.
- At a frequency of 2 kHz, check that the trigger level can be adjusted over 7 cm by means of LEVEL (R9).
- Turn LEVEL (R9) fully anti-clockwise (not in position AUT) and fully clockwise. The time-base generator should be switched off in both extreme positions.
- Increase the amplitude of the input signal by a factor 2.25. In both extreme positions of LEVEL (R9), the time-base generator may not be switched off.
- Check that no double trace arises when the time coefficient is varied with V/cm (R8).

b. External

- Set INT-EXT (SK10) to position EXT.
- Apply a voltage of 1 V_{p-p}, coming from the same voltage source as the voltage applied to 1 MΩ//30 pF (BU2), to terminal TRIGG (BU5).
- Check that a properly triggered display is obtained at frequencies of 10 Hz and 2 MHz.

c. Automatic

- Set LEVEL (R9) to position AUT.
- Set TIME/cm (SK6) to position 200 μsec/cm.
- Set INT-EXT (SK10) to position INT.
  Without input signal, a time base line should be displayed on the screen.
- Apply a sinusoidal voltage having a frequency of 20 Hz and 1 MHz to 1 MΩ//30 pF (BU2).
- Check that a triggered display is obtained at a trace height of 5 mm.

d. T.V. frame and T.V. line

- Set TIME/cm (SK7) to position T.V. FRAME.
- Set + /— (SK9) to position —.
- Apply a positive video signal to socket 1 MΩ//30 pF (BU2).
  At a trace height of 4 mm (synchronising signal), a trace triggered on the frame pulse should be displayed.
- Set TIME/cm (SK7) to position T.V. LINE.
- Check that a trace is displayed which has been triggered on the line synchronising pulse.

– Repeat both checks with a negative video signal and + /— (SK9) in position +.

3. Time coefficients

– Set TIME/cm (SK7) to position 1 msec.
– Set TIME/cm (R8) to position CAL.
– Set MAGN (SK2) to position X1.
– Apply a square-wave voltage having a frequency of 1 kHz to 1 MΩ// 30 pF (BU2).
– By means of R536, adjust the time coefficient so that, measured across the centre 8 cm, 8 complete periods are displayed.
– Adjust the trace width to 11 cm by means of R546.
– Recheck the time coefficient. If necessary, readjust R536.
– Set TIME/cm (SK7) to position. 5 msec.
– Increase the frequency of the input signal to 2 kHz.
– Check the time coefficient across the centre 8 cm.
Tolerance + or — 1%. Correction is possible with R595.
– Check the time coefficient in all positions of TIME/cm (SK7) across the centre 8 cm of the screen.
Tolerance in all positions except .5 sec.: + or —2% (at final check: + or —4%), with respect to the value given on the text plate.
Tolerance in position .5 sec.: + or —5% (at final check: + or — 7%).
– Check the time coefficient in position T.V. LINE. This should be 10 μs/cm, + or —10%.
– Check the time coefficient in position T.V. FRAME. This should be 0.5 ms/cm, + or —10%.
– Check that the trace width is at least 9 cm in all positions of TIME/ cm (SK7).
– Check that the control range of TIME/cm (R8) is 1 : 5 to 1 : 6 when TIME/cm (SK7) is in position T.V. LINE or T.V. FRAME.
– Check that the control range in the remaining positions of TIME/cm (SK7) is 1 : 2.6 to 1 : 3.5.
– Set MAGN (SK2) to position X5.
– When X-SHIFT (R3) is fully anti-clockwise or fully clockwise, it should be possible to display the end of the time base line.
– Set TIME/cm (SK7) to position 50 μsec.
– Apply a signal of 20 kHz to socket 1 MΩ//30 pF (BU2).
– Check that the width of 1 period is 5 cm, + or —10%.

- Set MAGN (SK2) to position X2.
- Check that the width of 1 period is 2 cm, + or —10%.

4. Linearity

- Set MAGN (SK2) to position X1.
- Set TIME/cm (SK7) to position .5 μsec.
- Apply a sinusoidal voltage having a frequency of 2 MHz to 1 MΩ//30 pF (BU2).
- Adjust the picture symmetrically around the screen centre by means of Y-SHIFT (R6).
- Across the centre 8 cm, measure the difference in period width between the two most deviating periods.
  This may not exceed 1 mm.
- Set MAGN (SK2) to position X5 and repeat the above check.

5. Beam deflection

- Set TIME/cm (SK1) subsequently to positions 0.5, 1 and 2 μsec.
- Check that the flyback of the sawtooth voltage is suppressed and that the intensity of the time base line is constant along its entire length.

6. Sawtooth voltage on terminal TIME BASE (BU8)

Check that this voltage has a value of at least 8 V_{p-p}.

7. Z-Modulation

- Apply a voltage of 20 V_{p-p} having a frequency of 2 kHz to terminal Z-MOD (BU6).
- Externally trigger the instrument with this brightness modulation voltage.
- Check that the trace is displayed in light and dark at normal intensity.

H. ATTENUATOR PROBE PM 9326A/10

- Connect the attenuator probe to socket 1 MΩ//30 pF (BU2).
- Set V/cm (SK6) to position 0.02 V/cm and V/cm (R7) to position CAL.
- Set X1-X10 (SK5) to position X1.
- Apply a square-wave voltage of 1.6 V_{p-p}, 2 kHz, to the probe and check the square-wave response (permissible overshoot 2%).
  If necessary, readjust the trimmer in the probe.

This is effected as follows (Fig. 11):

- Loosen ring 2 while holding jacket 1.
- Hold jacket 1 and trim probe 3 until the reproduction of the applied voltage is satisfactory.
- Tighten ring 2 again.

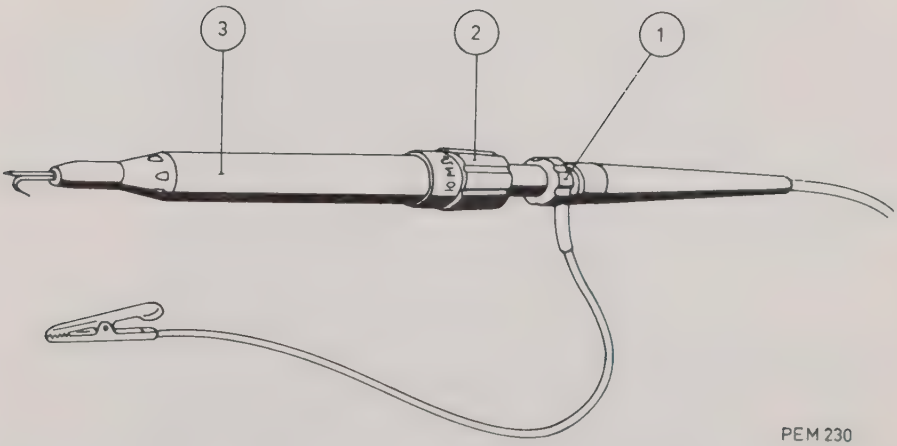


Fig. 11. Adjusting the trimmer in the measuring probe

Replacing parts

XII

During the replacement of parts, the instrument should be switched off.

A. REPLACING THE CATHODE RAY TUBE

- Remove the high voltage connection.
- Remove the text plate with bezel, measuring graticule and contrast plate.
- Remove the tube holder.
- Unscrew screw S (Fig. 16).
- Push the tube out of the oscilloscope via the opening at the front.
- Check, when a new tube has been fitted, that the time base line is horizontal. If necessary, set the tube to the correct position with lever L (Fig. 16).
- Readjust the instrument according to chapter XI.

B. TRANSISTOR TS1001

- Remove the cable compartment at the rear of the instrument (2 screws; watch the spacers).
- Remove the hard paper plate which is then released (2 screws). Transistor TS1001 can then be replaced.

C. DISASSEMBLING MEASURING PROBE PM 9326A/10 (Fig. 12)

- Unscrew measuring hook 1 from the measuring probe.
- Remove earthing flex 6 from the probe.
- Unscrew stator 2 from the tube.
- The resistor with bushing 12 and compression spring 4 can then be removed from the probe.
- Unscrew rotor 3 from the tube.
- Remove set-screw 5.
- Detach the probe cable from rotor 3.

D. REPLACING THE PROBE CABLE

The attenuator probe is provided with a cable having a thin core.
When replacing, proceed as follows:

a. At the probe side

- Remove sections 2 and 3 from the probe, shown in Fig. 13.
- Remove the earthing flex.
- Slide cable grommet "a" off bushing "b".
- Remove pin "c".
- Heat up soldering point "d" and at the same time pull bushing "b" so that the assembly is removed from the cable.

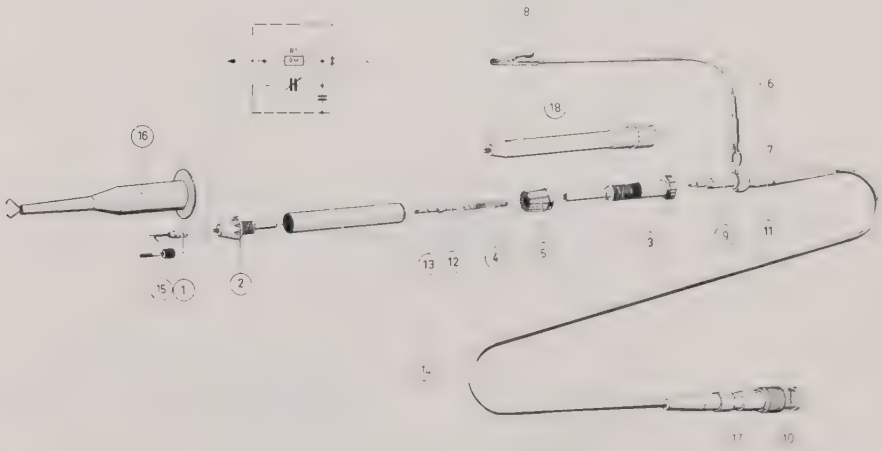


Fig. 12. Mounting diagram of the attenuator measuring probe

- Remove the outer jacket of the new cable over a length of 32 mm.
- Remove screening "f" over a length of 27 mm.
- Remove core insulation "g" over a length of 15 mm.
- Slide bushing "b" onto the cable until it reaches the core insulation. The core of the cable then protrudes through the hole at the front.
- Replace pin "c" in the opening at the front, thus securing the core of the cable.
- Cut off the protruding part of the core and the pin at a distance of 1 mm from the plug.
- Solder screening "f" onto bushing "b".
- Slide grommet "a" over bushing "b".
- Refit the earthing flex.

b. At the side of the BNC connector

- Remove pin "c".
- Remove grommet "h".

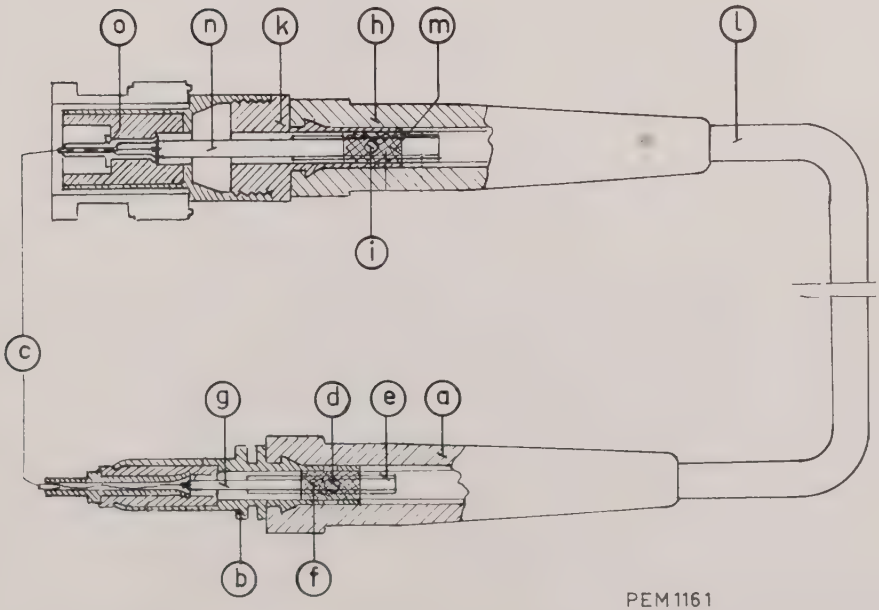


Fig. 13. Mounting diagram of the measuring probe cable

- Heat up soldering point "i" and pull the cable out of nut "k".
- Remove outer insulation "l" of the new cable for a length of 35 mm, the screening "m" for a length of 29 mm and the inner insulation "n" for a length of 10 mm.
- Slide the cable into the BNC connector until core "n" touches contact pin "o".
- The wire itself then protrudes through the contact pin.
- Secure the wire by replacing the pin in the contact pin.
- Cut off the protruding part of the pin.
- Solder the screening "m" to nut "k" at point "i".

Assistance in fault finding

XIII

A. VOLTAGES OF THE SUPPLY TRANSFORMER

The available non-loaded voltages are given in the form of a table with the drawing of the supply transformer.
The loaded voltages are indicated in the circuit diagram of the supply section.

B. VOLTAGES AND VOLTAGE SHAPES IN THE INSTRUMENT

The d.c. levels on the electrodes of the valves and the semiconductors are indicated at the relevant points in the drawings on the print plates and the circuit diagrams.
The voltage shapes have been measured as follows:

- A sinusoidal voltage of 80 mV_{p-p}, 2 kHz on input socket 1 MΩ//30 pF.
- V/cm (SK6) in position .01 V/cm.
- V/cm (R7) in position CAL.
- TIME/cm (SK7) in position .1 msec.
- TIME/cm (R8) in position CAL.
- LEVEL (R9) in position AUT.
- MAGN (R1) in position X1.
- AC-O-DC (SK4) in position AC.
- X1-X10 (SK5) in position X1.
- +/— (SK9) in position +.
- INT/EXT (SK10) in position INT.
- X-SHIFT (R3) and Y-SHIFT (R6) in their mid positions.

The d.c. levels have been measured under the same conditions, except those in the Y-amplifier which have been measured without input signal.
The d.c. values have been measured with a valve voltmeter.
These values may deviate slightly for each oscilloscope.

C. REMARKS

In case of defects, one can always apply to the world wide PHILIPS Service Organisation.
When the instrument is to be forwarded to a PHILIPS service workshop for repairs, the following points should be observed.

- Tie on a label bearing full name and address of the sender.
- Indicate as completely as possible the symptom(s) of the fault(s).
- Carefully pack the instrument in the original packing, or, if this is no longer available, in a wooden crate.
- Send the instrument to the address provided by your local PHILIPS representative.

List of parts

XIV

A. MECHANICAL PARTS

Item	*Fig.*	*Quantity*	*Code number*	*Description*	*S*
1	14	1	4822 159 00573	Instruction plate PM 3221	**
			4822 159 00579	Instruction plate PM 3220	**
2	14	1	4822 413 50426	Knob (R1)	**
3	14	3	4822 413 50427	Knob (R3, SK2, SK3)	**
4	14	1	4822 157 00728	Contact pin	**
5	14	1	4822 163 01007	Grommet	**
6	14	3	4822 159 00421	Sliding switch, 2-pole (SK5, SK9, SK10)	*
7	14	4	M7 774 08	Connection terminal	*
8	14	2	4822 159 00366	Earthing terminal	*
9	14	2	4822 159 00315	Control knob, diam. 14 mm, shaft diam. 6 mm.	**
10	14	2	4822 159 00314	Lid for knob, item 9	**
11	14	2	4822 159 00359	Control knob, diam. 14 mm, shaft diam. 6 mm.	**
12	14	2	4822 159 00358	Lid for knob, item 11	**
13	14	2	4822 159 00318	Switch knob, diam. 22 mm	**
14	14	1	4822 158 00421	BNC connector, BU2	*
15	14	4	4822 159 00575	Base	**
16	14	1	4822 159 00571	Instruction plate, lower	**
17	14	2	4822 157 00714	Sliding switch, 3-pole (SK3, SK4)	*
18	14	1	4822 159 00572	Knob (R4)	**
19	14	1	4822 159 00574	Measuring graticule	*
20	14	1	M7 113 92	Contrast plate	*
21	14	1	4822 157 00725	Grip	**
22	14	2	4822 159 80006	Ornamental profile	**
23	15	1	M7 737 11	Mains voltage adapter	**
24	15	1	F 101 AA/001	Fuse holder	**
25	15	1	4822 159 00569	Cable compartment	**
26	16	5	4822 157 00732	Lamp holder	**
27	16	1	M7 289 49	Anode contact	*
28	16	1	4822 273 60041	Attenuator switch	**
29	16	10	4822 404 50127	Print terminal	**
30	16	6	976/PW9×12	Valve holder, noval	**
31	16	1	4822 255 70099	Valve holder (cathode ray tube)	**

Item	*Fig.*	*Quantity*	*Code number*	*Description*	*S*
32	16	220 cm	4822 320 40022	Delay line (only for PM 3221)	
33	17	1	4822 163 01068	Spacer	**
34	17	1	4822 273 80072	Time-base switch	**
35	17	1	4822 273 30101	Magnifier switch	
36	17	1	910/18×110	Mounting strip	**
		1	971/71	Switch oil	**

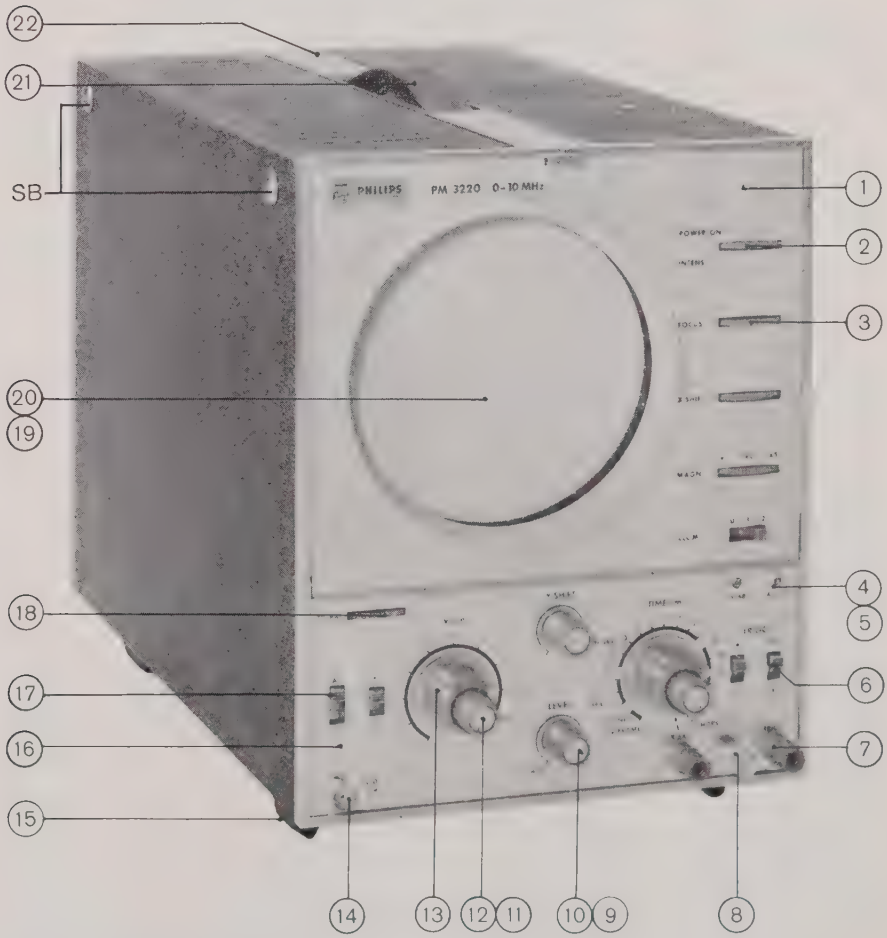


Fig. 14. Front view with item numbers

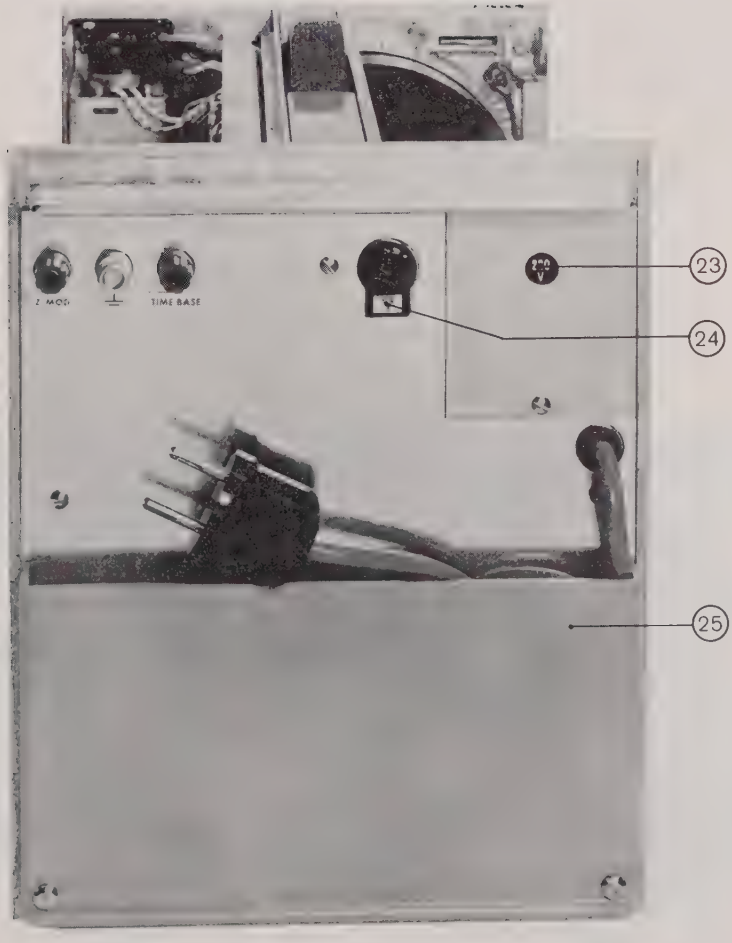


Fig. 15. Rear view with item numbers

PARTS OF PROBES PM 9326A/10 AND PM 9325 (Fig. 12)

Item	*Quantity*		*Code number*	*Description*	*S*
	PM 9326	PM 9325			
1	1	1	M7 716 44	Measuring hook	*
2	1		M7 755 33	Stator	*
3	1		M7 759 05	Rotor	*
4	1		M7 216 05	Pressure spring	*
5	1		M7 698 27	Set nut	*
6	15 cm	15 cm	R 783 KA/03J	Cable	*
7	1	1	M7 289 60	Cable shoe	*
8	1	1	978/8	Crocodile clip	*
9	1	1	M7 604 00	Plug	*
10	1	1	4822 158 00455	BNC connector	*
11	1	1	P5 656 94/JE	Cable grommet	*
12	1		M7 292 03	Bushing	*
13	1		M7 632 58	Resistor	*
14	1 m	1 m	R 209 KA/15	Cable	*
15	1	1	M7 343 31	Plug pin	*
16	1	1	M7 731 81	Measuring terminal	*
17	1	1	4822 157 00731	Cable nut	*
18		1	4822 159 00365	Measuring probe 1 : 1	*
19	1	1	4822 321 20087	Measuring probe cable, complete	*

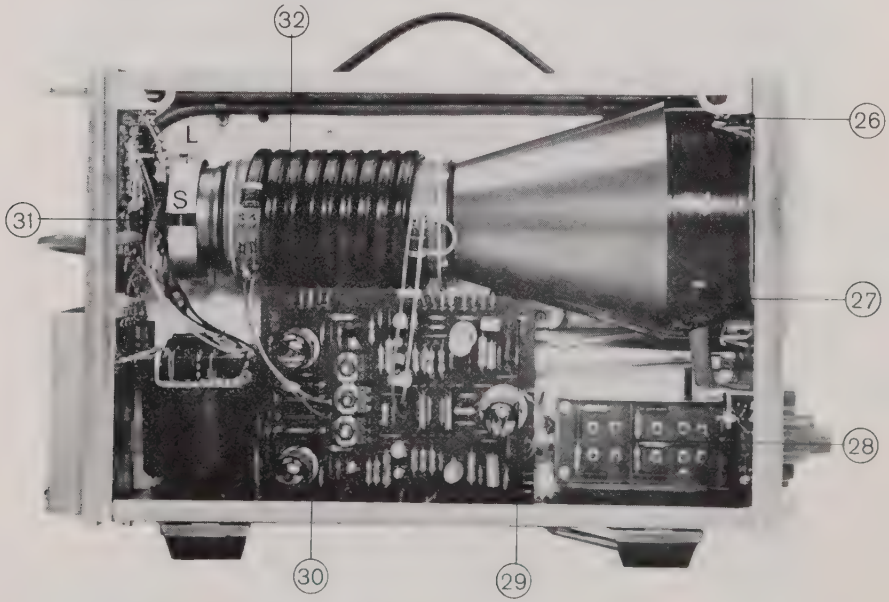


Fig. 16. Left side view with item numbers

PURPOSE OF THE COLUMN "S"

– Components not marked

They should be present at the Service Department in the country concerned or at the customer who is using the apparatus.
They include:
a. all electrical components;
b. mechanical parts which are vulnerable, or which are subject to wear.

– Components marked with one star

These components generally have a long or unlimited service-life, but their presence is essential for the correct working of the apparatus. Stocking up of a few of these components depends on the following factors:
a. the number of equipment present in the country concerned,
b. the necessity of having the apparatus working continuously or not,
c. the time of delivery of the components with respect to the import restrictions in the country concerned and the duration of the transport.

– Components markd with two stars

These components have a long or unlimited service-life and they are not essential for the correct working of the apparatus. Generally they are not stocked locally.

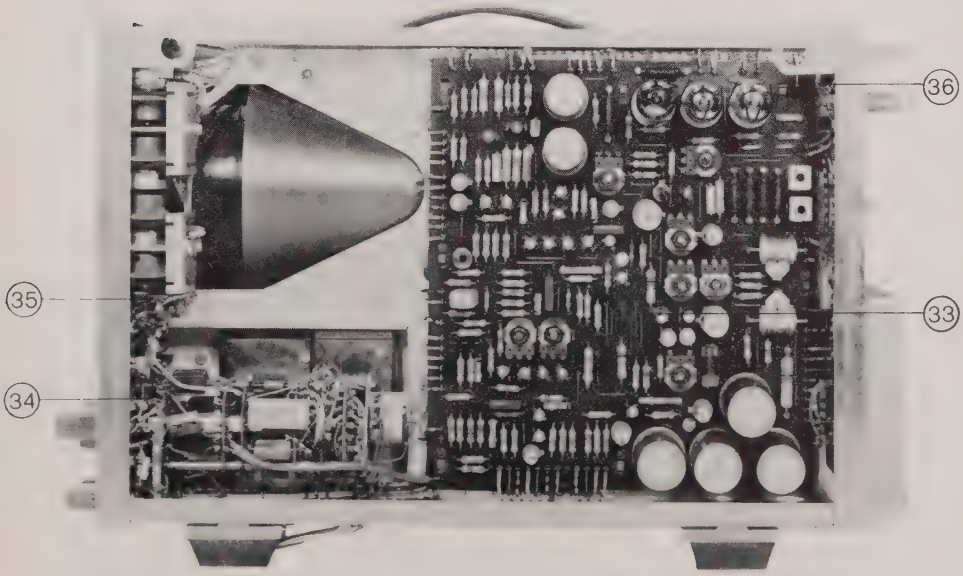


Fig. 17. Right side view with item numbers

B. ELECTRICAL PARTS

No standard parts are included in this parts list with the exception of choice resistors.
The standard parts in the circuit diagram are indicated with symbols from which the service code number can be derived.
The key to the code is given below:

	Carbon resistor	0.25 W	⩽ 1 MΩ:	5%	902/K . . .
			> 1 MΩ:	10%	
	Carbon resistor	1 W	⩽ 2.2 MΩ:	5%	900/P . . .
			> 2.2 MΩ:	10%	
	Carbon resistor	0.5 W	⩽ 10 MΩ:	1%	901/. . .
			> 10 MΩ:	2%	
	Carbon resistor	0.5 W	⩽ 1.5 MΩ:	5%	902/P . . .
			> 1.5 MΩ:	10%	
	Wire-wound resistor	5.5 W	⩽ 270 Ω:	10%	938/A . . .
			> 270 Ω:	5%	
	Carbon resistor	0.125 W		5%	902/A . . .
	Ceramic capacitor	500-700 V			904/. . .
	Styroflex capacitor	500 V		1%	905/D . . .
	Polyester capacitor	400 V		10%	906/. . .
	Ceramic trimmer (⩽ 22E) Air trimmer (⩾ 30E)				908/. . .

Example:

	Code number	901/120K
	Code number	904/4E7

The correct values of the choice-resistors and capacitors are determined during factory adjustment. All resistors are vaporized carbon resistors, unless otherwise specified.

B. ELECTRICAL PARTS

Capacitors

Item	*Code number*	*Value*	*Operating Voltage*	*Tolerance*	*Description*
C16	B1 530 75	0.1 μF	600 V		Paper
C41	4822 069 01027	10 nF	250 V	10 %	Metal polyester
C42	909/W80	80 μF	16 V		Electrolytic
C44	4822 069 01068	12 nF	250 V	10 %	Metal polyester
C46	4822 069 01032	32 μF	100 V		Electrolytic
C48	904/				Ceramic (choice)
C301	4822 143 00591	15 nF	1.6 kV	10 %	Paper
C302	4822 069 01027	10 nF	250 V	10 %	Metal polyester
C502	909/G6.4	6.4 μF	10 V		Electrolytic
C504	4822 069 00628	470 nF	250 V	10 %	Metal polyester
C505	4822 069 00601	330 nF	250 V		Metal polyester
C513	909/W80	80 μF	16 V		Electrolytic
C514	909/W80	80 μF	16 V		Electrolytic
C517	909/Z32	32 μF	40 V		Electrolytic
C519	909/W2.5	2.5 μF	16 V		Electrolytic
C522	4822 069 01027	10 nF	250 V	10 %	Metal polyester
C526	909/Z10	10 μF	64 V		
C528	4822 141 00242	1 μF			Electrolytic
C529	see C528	100 nF			
C530	see C528	10 nF			Box capacitor
C531	905/D950E par. 905/D24E	975 pF	500 V		Mica
C532	905/D300E par. 905/D75E	375 pF	500 V		Mica
C533	905/D160E par. 905/D10E	170 pF	5000 V		Mica
C535	4822 141 00243	10 μF			Box capacitor
C544	4822 069 00622	1 μF	250 V	10 %	Metal polyester
C546	4822 069 01063	150 nF	250 V	10 %	Metal polyester
C547	909/W10	10 nF	16 V		Electrolytic
C703	4822 069 01027	10 nF	250 V	10 %	Metal polyester
C1001	4822 069 01031	64 μF	300 V		Electrolytic
C1002	4822 069 00928	100 μF	40 V		Electrolytic
C1003	4822 069 01031	64 μF	300 V		Electrolytic
C1004	4822 124 40055	250 μF	100 V		Electrolytic
C1006	4822 124 40055	250 μF	100 V		Electrolytic
C1007	909/W250	250 μF	16 V		Electrolytic
C1008	4822 069 00878 par.	1250 μF	25 V		Electrolytic
C1009	909/W125	125 μF	16 V		Electrolytic
C1010	4822 121 40095	120 nF	250 V		Metal polyester

Item	*Code number*	*Value*	*Operating Voltage*	*Tolerance*	*Description*
C1101	909/W125	125 µF	16 V		Electrolytic
C1102	4822 069 01064	100 nF	250 V	10 %	Metal polyester
C1103	4822 069 01064	100 nF	250 V	10 %	Metal polyester
C1104	4822 143 00591	15 nF	1.6 kV		Paper
C1106	4822 143 00591	15 nF	1.6 kV		Paper
C1107	4822 143 00591	15 nF	1.6 kV		Paper
C1108	4822 143 00591	15 nF	1.6 kV		Paper

Resistors

Item	*Code number*	*Value*	*Power*	*Tolerance*	*Description*
R1	916/DE1M	1 MΩ			Potentiometer, lin.
R2	916/DE1M	1 MΩ			Potentiometer, lin.
R3	916/GE20K	20 kΩ			Potentiometer, lin.
R4	4822 071 00802	220 Ω			Potentiometer, lin.
R5	4822 071 00636	2200 Ω			Potentiometer, lin.
R6	4822 071 00636	2200 Ω			Potentiometer, lin.
R7	4822 140 00356	500 Ω			Potentiometer, lin.
R8	4822 071 00953	22 kΩ			Potentiometer, lin.
R9	4822 971 00714	5 kΩ			Potentiometer, lin.
R16	B8 305 23D/900K	900 kΩ	0.1 W	1 %	Carbon
R17	B8 305 23D/111K	111 kΩ	0.125 W	1 %	Carbon
R18	B8 305 23D/990K	990 kΩ	0.1 W	1 %	Carbon
R19	B8 305 23D/10K1	10.1 kΩ	0.125 W	1 %	Carbon
R21	4822 111 20236	999 kΩ	0.1 W	1 %	Carbon
R22	E 003 AB/D1K	1 kΩ	0.125 W	1 %	Carbon
R24	901/1M (2 par.)	500 kΩ	0.125 W	1 %	Carbon
R26	B8 305 23D/1M	1 MΩ	0.1 W	1 %	Carbon
R27	B8 305 23D/800K	800 kΩ	0.1 W	1 %	Carbon
R28	E 003 AB/D250K	250 kΩ	0.125 W	1 %	Carbon
R35	938/A27E	27 Ω	5.5 W	5%	Wire wound
R71	4822 101 20154	220 Ω			Potentiometer, lin.
R73	4822 101 20154	220 Ω			Potentiometer, lin.
R74	4822 071 01022	10 kΩ			Potentiometer, lin. (only for PM 3221)
R312	4822 071 00712	470 kΩ			Potentiometer PW
R313	4822 071 00712	470 kΩ			Potentiometer PW
R536	4822 071 00656	4.7 kΩ			Potentiometer PW
R546	4822 071 00636	2.2 kΩ			Potentiometer PW
R594	B8 305 23D/250K	125 kΩ			Carbon (2 par.)
R596	901/1M (2 par.)	500 kΩ			Carbon

Item	*Code number*	*Value*	*Power*	*Tolerance*	*Description*
R713	4822 071 00636	2.2 kΩ			Potentiometer PW
R1004	4822 101 20154	220 Ω			Potentiometer, lin.
R1014	4822 071 00635	1 kΩ			Potentiometer PW
R1018	4822 071 00635	1 kΩ			Potentiometer PW

Miscellaneous parts

Item	*Code number*	*Description*
T1001	4822 168 01102	Supply transformer
T1100	4822 117 00516	High voltage transformer
VL1001	974/V1000	Fuse
VL1002	A3 425 53	Fuse
VL1003	974/V1000	Fuse
L1	4822 157 50175	Coil
L2	4822 157 50175	Coil
L3	4822 157 50175	Coil
L4	4822 157 50175	Coil
L501	4822 207 00365	Coil
L502	4822 207 00365	Coil
L1001	4822 108 00589	Coil
U2	4822 159 00576	Print plate complete with parts (Y-amplifier)
U3	4822 159 00577	Print plate complete with parts (time base, X-amplifier, supply)
U4	4822 159 00578	Print plate complete with parts (high voltage unit)

Valves

Number	*Type*	*Number*	*Type*
B1	E188CC	B303	GL8
B2	ECC88	B701	E810F
B3	ECC88	B702	E180F
B301	D13-27GH	B1001	ECC88
B302	GL8	B1002	ZZ1000

Transistors

Number	*Type*	*Number*	*Type*
TS1	AF124	TS10	AF124
TS2	AF124	TS11	AF118
TS3	AF124	TS12	AF124
TS4	AF124	TS13	AF124
TS6	AF124	TS501	AF186
TS7	AF124	TS502	AF186
TS8	AF124	TS503	BSY39
TS9	AF118	TS504	BSY39
		TS505	AF124

Number	*Type*	*Number*	*Type*
TS506	ASZ21	TS517	AF124
TS507	ASZ21	TS518	BC107 or BF115
TS508	AF124	TS519	BC107 or BF115
TS509	2N930	TS520	2N929
TS511	2N929	TS1001	ASZ16
TS512	AF124	TS1002	AC128
TS513	AF124	TS1003	AF118
TS514	AF124	TS1004	AF118
TS516	AF124	TS1101	ASZ18

Transistors TS1-2-3-4-9-11-501 and 502 should be selected as a matched pair. (tol. 10%) with respect to the h_{fe} factor in the range $50 \leqslant h_{fe} \leqslant 250$. Moreover TS501 and TS502 should have an $I_{ceo} < 50\ \mu A$.

Diodes

Number	*Type*	*Number*	*Type*
GR1	OA202	GR1007	BYY20
GR3	OA95	GR1008	OA202
GR4	OA95	GR1009	OA202
GR501	AAZ15	GR1101	BYX11
GR502	BAY38	GR1102	BYX11
GR1003	BYY21	GR1103	BYX11
GR1004	BYY20	GR1104	BYX11
GR1006	BYY21		

Zener diodes

Number	*Type*	*Number*	*Type*
GR2	BZY59	GR1011	OAZ212
GR503	BZY62	GR1106	BZY59

Rectifier cells

Number	*Type*
GR1001	B250 C125
GR1002	B125 C140

Lamps

Number	*Type*
LA1001 . . . LA1005	6828

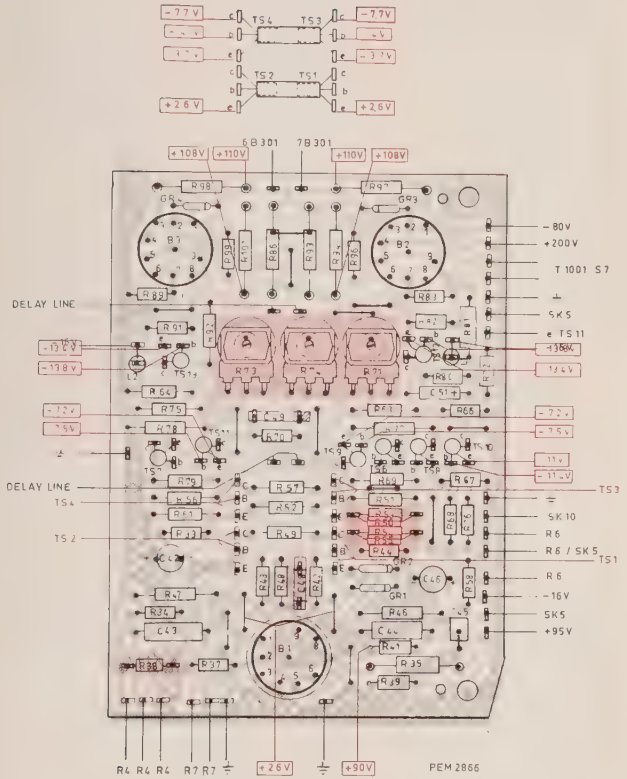
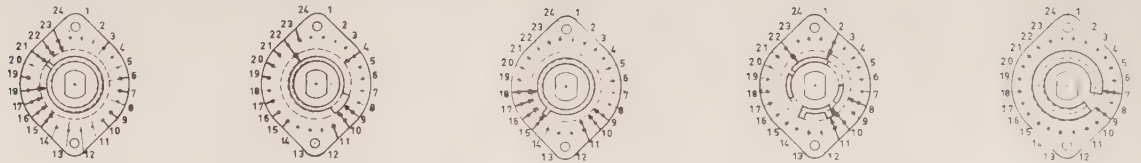
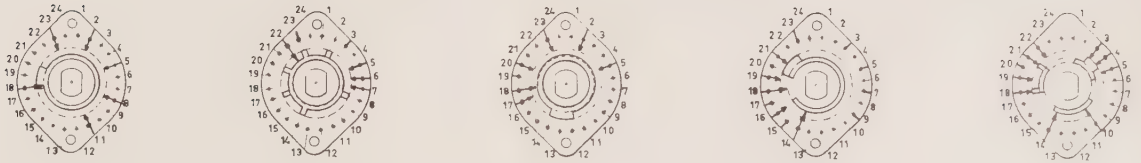


Fig. 18. Print plate U2, Y-amplifier (R74 and C49 for PM3221 only).
Erratum: C45 has been mounted on unit U3.

CONTACTS ON THE FRONT SIDE OF THE WAFER



I II III IV V



CONTACTS ON THE REAR SIDE OF THE WAFER, SEEN FROM THE FRONT SIDE

SK 7

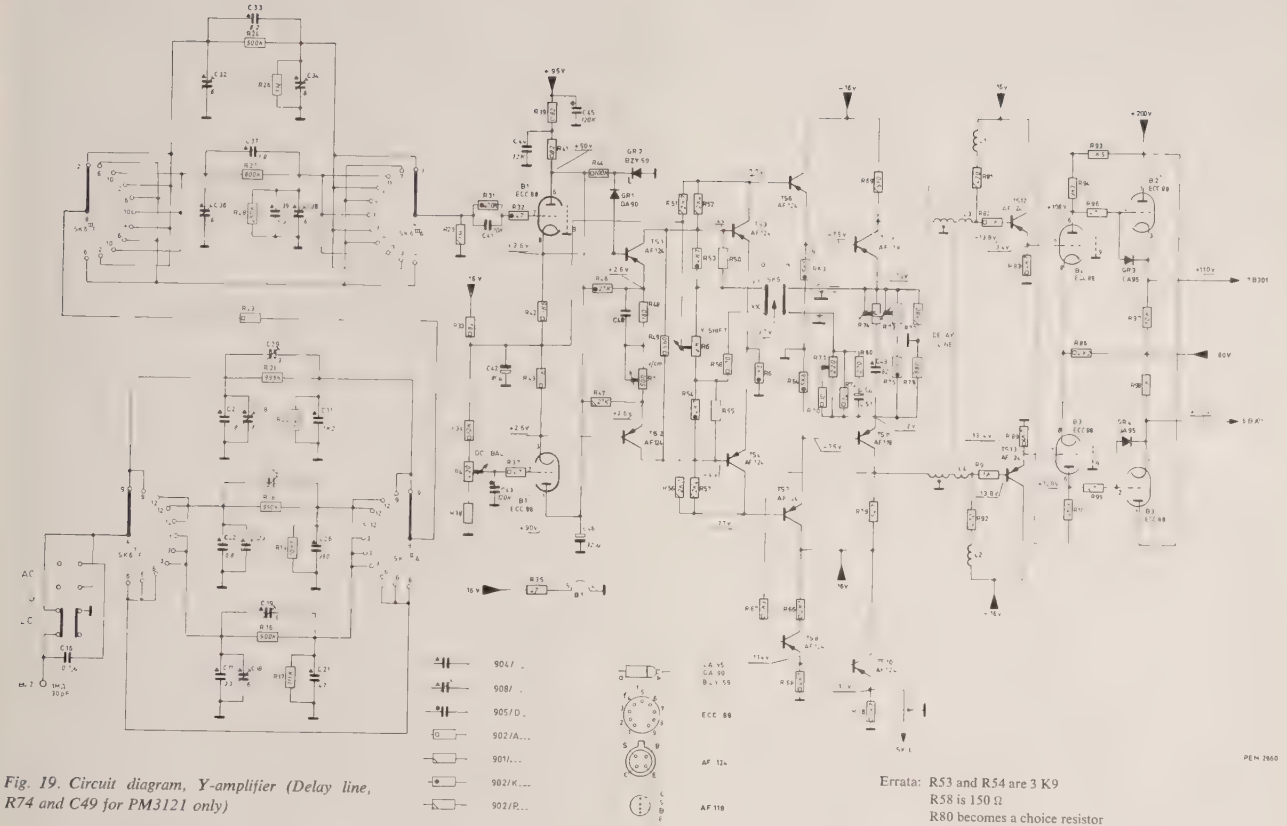
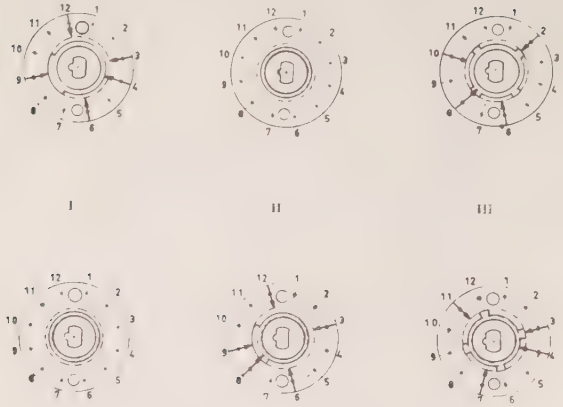


Fig. 19. Circuit diagram, Y-amplifier (Delay line, R74 and C49 for PM3121 only)

Errata: R53 and R54 are 3 K9
R58 is 150 Ω
R80 becomes a choice resistor

CONTACTS ON THE FRONT SIDE OF THE WAFER



CONTACTS ON THE REAR SIDE OF THE WAFER, SEEN FROM THE FRONT SIDE

SK 6

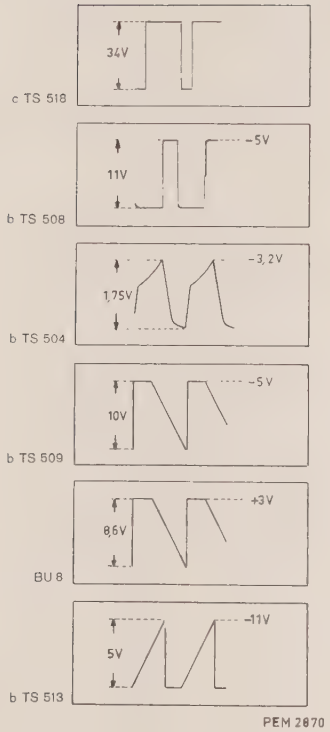


Fig. 20. Oscillograms

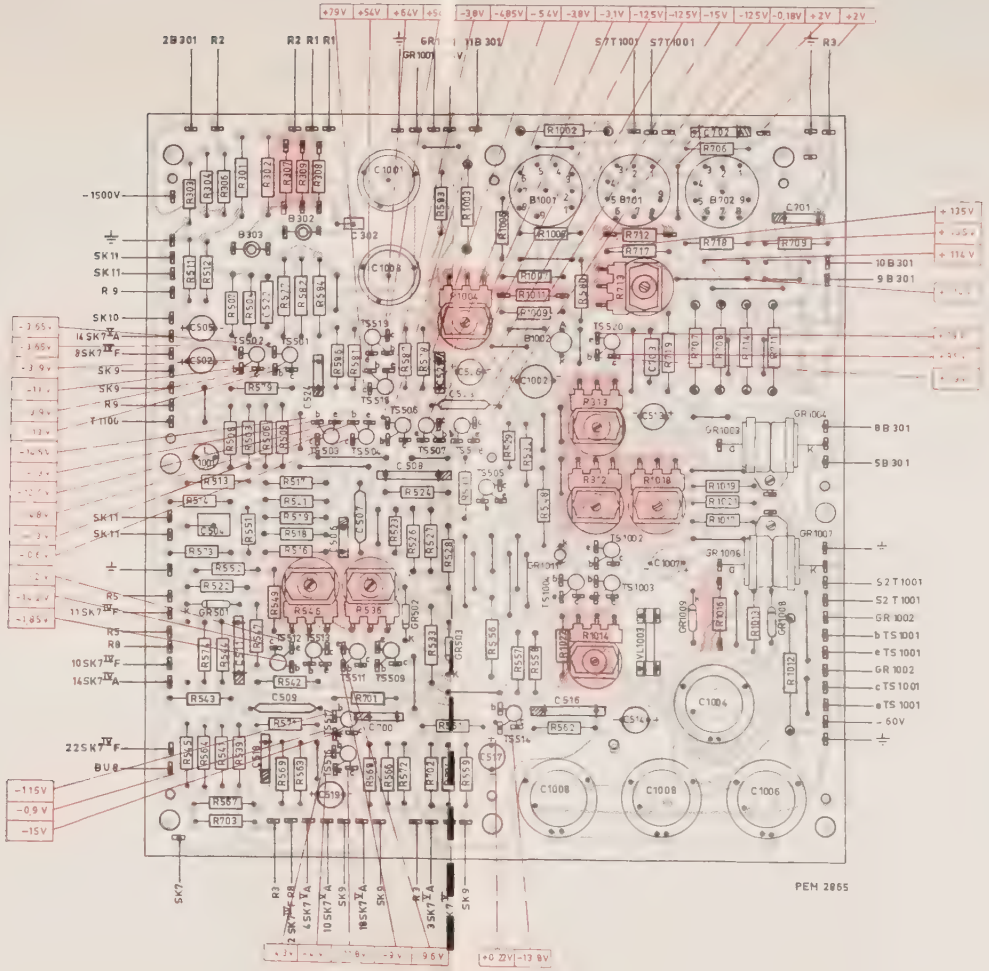
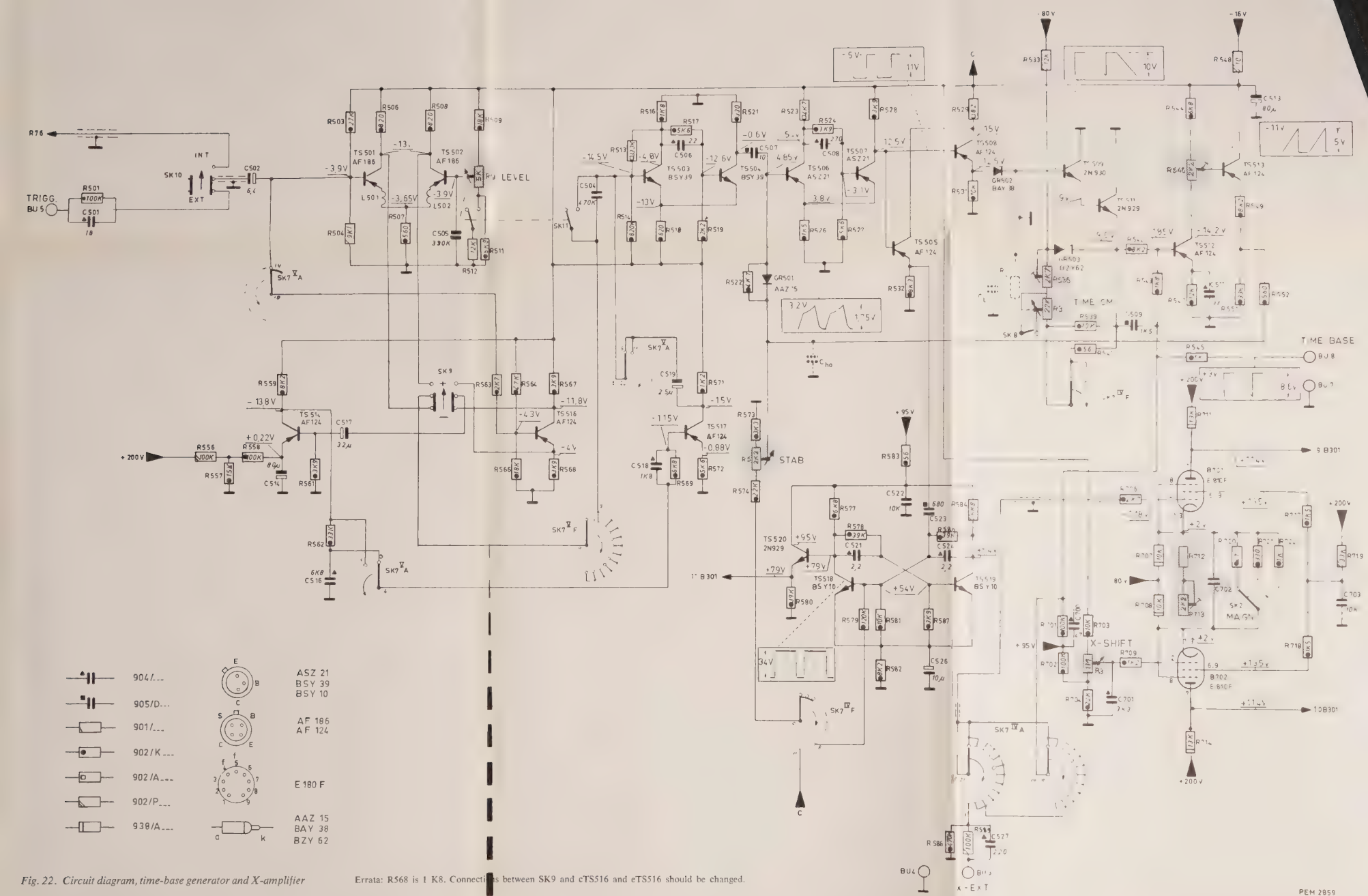
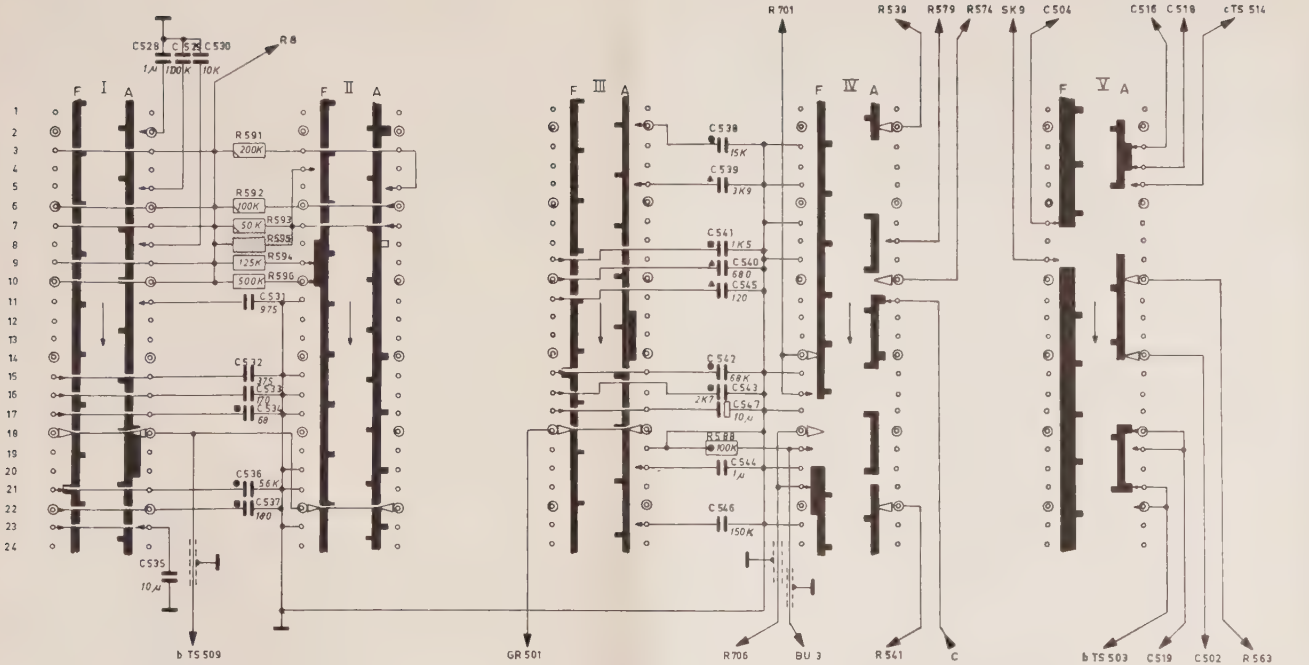


Fig. 21. Print plate U3, time-base generator, X-amplifier, supply section


TRIGG
BU 5
R501
100K
C501
18
INT
EXT
SK10
C502
6,4
R76
R503
R506
R508
R509
TS501
AF186
TS502
AF186
LEVEL
L501
L502
R504
R507
R560
C505
330K
R511
R512
SK7 A
SK9
R559
8K2
TS514
AF124
C517
32µ
R556
100K
R558
100K
8K8
C514
R557
15K
R561
3K3
+200V
R562
12K
6K8
C516
SK7 F
SK7 A
R563
2K7
R564
2K7
R567
3K3
TS516
AF124
R566
8K2
R568
3K3
C504
470K
SK11
R513
100K
R514
8K2
R516
1K8
R517
5K6
C506
22
R518
8K2
R519
2K2
R521
220
TS503
BSY39
C507
10
TS504
BSY39
R522
4K7
GRS01
AAZ15
R523
2K7
R524
7K9
C508
270
TS506
AS221
TS507
AS221
R525
1K5
R526
5K6
R527
5K6
R528
1K5
TS505
AF124
R532
2K2
C519
2,5µ
R571
1K2
C518
1K8
R569
6K8
R572
6K8
TS517
AF124
R573
1K2
R574
2K2
SK7 F
SK7 A
SK7 F
SK7 A
SK7 F
SK7 A
R583
56
C522
10K
680
R584
4K7
R577
6K8
R578
39K
C521
2,2
C523
C524
2,2
TS520
2N929
TS518
BSY10
TS519
BSY10
R579
20K
R580
39K
R581
10K
R587
3K3
R582
2K2
C526
10µ
C527
220
R588
100K
BU4
x-EXT
BU3
R533
12K
R548
12K
C513
80µ
R534
4K8
C512
2µ2
R535
15K
GRS02
BAY38
R537
15K
TS508
AF124
TS509
2N930
TS511
2N929
R539
4K7
TS513
AF124
R540
2K2
R541
4K7
R542
4K7
TS512
AF124
R543
4K7
R544
4K7
R545
4K7
R546
4K7
R547
4K7
R552
4K7
R553
4K7
R554
4K7
R555
4K7
R536
2K7
R3
2K2
TIME CM
SK8
C509
1K5
R549
12K
R550
56
TIME BASE
BU8
BU7
R551
1K5
+200V
+4V
R711
1K5
9 B301
B701
E 810 F
+2V
+1,5V
+200V
R707
10K
R712
10K
R708
10K
80 V
C702
2K2
R713
2K2
SK2
MAGN
R720
1K5
R719
12K
C703
10µ
+2V
6,9
+1,5V
B702
E 810 F
+1,4V
10 B301
R710
12K
+200V
+95V
R702
100K
R701
100K
C700
10K
R703
10K
X-SHIFT
R709
1K2
R3
C701
2K2
R704
12K
SK7 A
+95V
-80V
-16V
-5V
11V
10V
-11V
5V
3,2V
1,75V
34V
+15V
-14,2V
-13,8V
+0,22V
-4,3V
-11,8V
-4V
-11,5V
-15V
-0,88V
+95V
+79V
+54V
-13,5V
-12,6V
-0,6V
4,65V
-14,5V
-4,8V
-3,9V
-3,65V
-13,5V
-3,1V
3,8V
12,5V
5,4V
5,6V
+9,5V
-14,2V
+5,4V
+2,4V
+2,4V
+2,4V
+1,4V
+1,4V
+1



905/D___
906/___
904/___
901/___
902/K___

Resistors R591, R592 and R593 should be selected within 1/2% tolerance. All three resistors should have identical tolerances i.e. all positive or all negative.

Erratum: Added in parallel to C534 a choice capacitor C548 to be able to adjust the highest sweep times

Fig. 23. Time-base switch

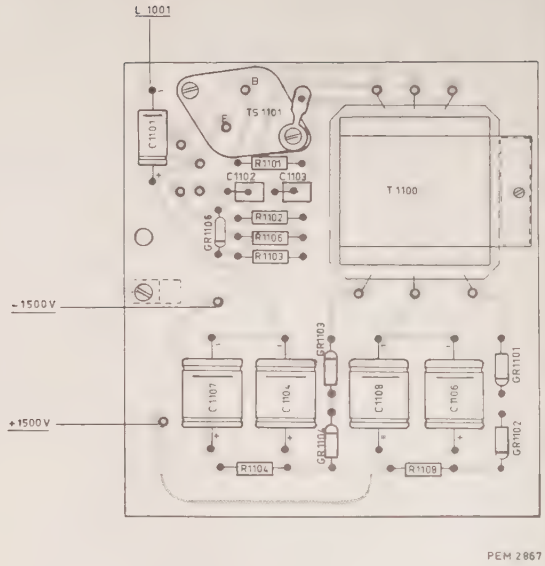
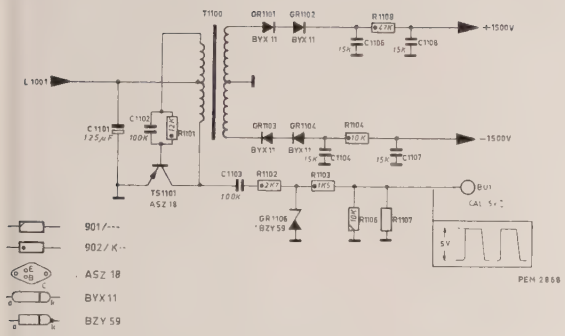
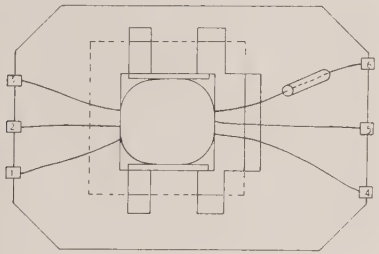


Fig. 24. Print plate U4, high voltage unit





CODE	TURNS
S1	25
S2	25
S3	2400
S4	2400

Fig. 25. Circuit diagram, high voltage unit

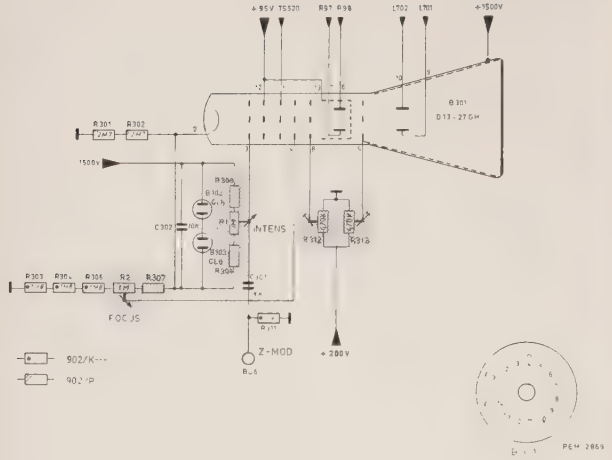
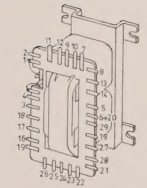


Fig. 26. Circuit diagram, CRT circuit



Code	1-2=15-16	3-4	17-18	7-8=21-22	5-6=19-20	9-10=23-24	11-12=25-26	13-14=27-28
Volts	110	15	20	219	34,4	22,8	7	7
Turns	500	68	86	1000	156	104	31	31

PEM 3025

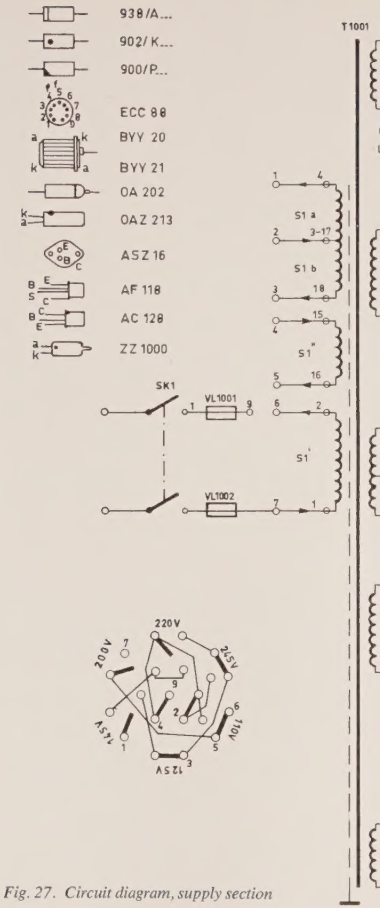


Fig. 27. Circuit diagram, supply section

Errata: Added:

C1009. Electrolytic, 125 μF, 16 V, 909/W125 between e TS1001 and earth.

C1010. Metal polyester, 120 nF, 250 V, 4822 121 40095 between 8 B1001' and earth.

Sales and service all over the world

Algérie: S.A. Philips Nord-Africaine, Immeuble Maurétana, Carrefour de l'Agha, Alger; tel. 647 200/1/2
Argentina: Philips Argentina S.A., Casilla Correo 3479, Buenos Aires; tel. T.E. 70, 7741 al 7749
Australia: Philips Electrical Ind. (Pty) Ltd., P.O.B. 2703 G.P.O., Sydney; tel. 20-223
België/Belgique: Philips S.A., 66 Boulevard de l'Impératrice, Bruxelles; tel. 13.44.44
Bolivia: Philips Sudamericana, Casilla 1609, La Paz; tel. 5270-5664
Brasil: Messrs. Inbelsa, Rua Amador Bueno 474, Sao Paulo; tel. 93-9191
Canada: Philips Electronic Industries, Electronic Equipment Division, 116 Vanderhoof Avenue, Toronto 17, Ontario; tel. Hudson 7-5161
Chile: Philips Chilena S.A., Casilla 2687, Santiago de Chile; tel. 35081
Colombia: Philips Colombiana S.A., Communications Department, Apartado Nacional 1505, Bogotá; tel. 473-640
Costa Rica: Philips de Costa Rica Ltd., Apartado Postal 4325, San José; tel. 5670
Curaçao: Philips Antillana N.V., Postbus 523, Willemstad; tel. Curaçao 36222-35464
Danmark: Philips A.S., Prags Boulevard 80, København; tel. Asta 2222
Deutschland (Bundesrepublik): Philips Industrie Elektronik GmbH., Postfach 14748, 2 Hamburg 63; tel. 501031
Ecuador: Philips Ecuador S.A.; Casilla 343, Quito; tel. 30064
Egypte: Resident delegate, P.O.B. 1687, Cairo; tel. 74993
El Salvador: Philips de El Salvador, Apartado Postal 865, San Salvador; tel. 7441
España: Philips Ibérica S.A.E., Paseo de las Délicias 65, Madrid; tel. 228 20 00
Ethiopia: Philips Ethiopia Priv. Ltd., Co., P.O.B. 659, Addis Abeba; tel. 13440
France: Philips Industrie S.A., 105 Rue de Paris, Bobigny (Seine); tel. 845 28-55, 845 27-09
Great Britain: The M.E.L. Equipment Company Ltd., Instrument House, 207 Kings Cross Road, London W.C. I; tel. Terminus 2877
Guatemala: Philips de Guatemala S.A., Apartado Postal 238, Guatemala City; tel. 20607-08-09
Hellas: Philips S.A. Hellénique, B.P. 153, Athènes; tel. 230476
Hong Kong: Philips Hong Kong Ltd., P.O.B. 2108, Hong Kong; tel. 33728, 28548
India: Philips India Ltd., PIT/S.E. Dept., Dugal House, 169 Backbay Reclamation, Bombay I; tel. 245144
Iran: Philips Iran Ltd., P.O.B. 1297, Teheran; tel. 48344-68344
Iraq: Philips (Iraq) W.L.L., IB/2/35 Masbah, Karradah Al-Sharquiyah, Baghdad; tel. 98844
Ireland: Philips Electrical (Ireland) Ltd., Newstead, Clonskeagh, Dublin 4; tel. 976611
Island: Mr. Snorri P.B. Arnar, P.O.B. 354, Reykjavik; tel. 13869
Israël: Isralectra Ltd., 12, Allenby Road, Haifa, P.O.B. 1608; tel. 54446, 54300
Italia: Philips S.p.A., Casella Postale 3992, Milano; tel. 69.94
Liban: Philips Liban S.A., P.O.B. 670, Beyrouth; tel. 232303-232458/59
Malaya: Philips Singapore Ltd., P.O.B. 1358 N.T.S. Building, d'Almeida Street, Singapore; tel. 94914
Maroc: Société Anonyme Marocaine de Télécommunications, Place Lemaigre Dubreuil, Casablanca; tel. 289-75

Mexico: Philips S.E.T., Apartado Postal 24-420, Mexico 7 D.F.; tel. 25-15-40
Nederland: Philips Bedrijfsapparatuur Nederland N.V., Boschdijk VB, Eindhoven; tel. 3-33-33
Ned. Antillen: Philips Antillana N.V., Postbus 523, Willemstad, Curaçao
New Zealand: Electronic Development and Applications Co. Ltd., 18-20 Lorne Street, P.O.B. 6415, Te Aro, Wellington; tel. 54-039
Nigeria: Philips (Nigeria) Ltd., Philips House, 6, Ijora Causeway, P.O.B. 1921, Lagos; tel. 56051/2
Nippon: Philips Products Sales Corporation of Japan, 24-9,3 chome, Nishi-Shimbasi, Minato-Ku, Tokyo
Nippon: Industrial Development & Consultant Co. Ltd., Nikkatsu International Building Room 420, Tokyo
Norge: Norsk A.S. Philips, Postboks 5040, Oslo; tel. 463890
Osterreich: Philips GmbH, Abt. Industrie, Triesterstrasse 64, 1101 Wien X; tel. 64 55 11
Pakistan: Philips Electrical Co. of Pakistan Ltd., Bunder Road, P.B. 7101, Karachi; tel. 70071
Paraguay: Philips del Paraguay S.A., Casilla de Correo 605, Asunción; tel. 8045-5536-6666
Perú: Philips Peruana S.A., Apartado Postal 1841, Lima; tel. 34620-40265
Philippines: Philips Industrial Development Inc., P.O.B. 2205, Ermita, Manila
Polska: Przedstawicielstwo, Firmy Philips W Polsce, ul Wt. Hibnera 5, Warszawa; tel. 629-66
Portugal: Philips Portuguesa S.A.R.L., Rua Joaquim Antonio d'Aquiar 66, Lisboa; tel. 683121/9
Rhodesia: Philips Rhodesian (Private) Ltd., P.O.B. 994, Gordon Avenue, Salisbury; tel. 29081
Rwanda: Philips Rwanda S.A.R.L., B.P. 449, Kigali
Schweiz-Suisse-Svizzera: Philips A.G., Binzstrasse 18, Zürich; tel. 051 25 86 10/ 27 04 91
South Africa: South African Philips (Pty) Ltd., P.O.B. 7703, 2, Herb Street, New Doornfontein, Johannesburg; tel. 24-0531
Suomi: Oly Philips Ab, Frederikinkatu 48, Helsinki; tel. 10915
Sudan: Gellatly Hankey & Co. (Engineering) Ltd., P.O.B. 150, Khartoum; tel. 71183
Sverige: Svenska A.B. Philips, Fack, Lidingöyägen 50, Stockholm 27; tel. 08/63500
Syrie: Philips Moyen Orient S.A., P.O.B. 2442, Damas; tel. 18605-21650
Taiwan: Yung Kang Trading Co. Ltd., 6 Nan King East Road, 1 Section, P.O.B. 1467, Taipei; tel. 43540
Thailand: Philips Thailand Ltd., 283 Silom Road, Bangkok; tel. 36985-8
Tunisie: Société Tunisienne d'Industrie Electronique et de Télévision, 32 bis Rue Ben Ghedhahem, Tunis
Türkiye: Türk Philips Ticaret A.S., Rosta Kutusu 504, Istanbul; tel. 447486
Uruguay: Philips de Uruguay, Avda Uruguay 1287, Montevideo; tel. 956 41-2-3-4
U.S.A.: Philips Electronic Instruments, New Product Development, 750 South Fulton Avenue, Mount Vernon N.Y.; tel. Mount Vernon 4-4500
U.S.A.: North American Philips Co. Inc., 100, East 42nd Street, New York 17, N.Y.
Venezuela: C.A. Philips Venezolana, Apartado Postal 1167, Caracas; tel. 72 01 51
Zambia: Philips Electrical Ltd., Freetown Road, P.O.B. 553, Kitwe
Zambia: Philips Electrical Ltd., P.O.B. 1878, Lusaka